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CONTENTS

The following list gives in full the abbreviated citations used after the titles of papers in this issue of GeoScience Abstracts.

Akademiya Nauk SSSR, Izvestiya, Geophysics Series, in English translation (American Geophysical Union). New York.
Alberta Society of Petroleum Geologists, Journal. Calgary.
American Association of Petroleum Geologists, Bulletin. Tulsa, Oklahoma.
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American Journal of Science. New Haven, Connecticut.
Association of American Geographers, Annals. Lawrence, Kansas.
California, Dept. of Water Resources, Bulletin. [Sacramento?].
California, Division of Mines, [Map]; Mineral Information Service. San Francisco.
California Highways and Public Works (California, Division of Highways, Dept. of Public Works). Sacramento.
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Engineering Journal. Montreal.
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Journal of Geological Education (National Association of Geology Teachers). Columbus, Ohio.
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Kentucky, University, Engineering Experiment Station, Bulletin. Lexington.
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Mineralogical Magazine (Mineralogical Society). London.
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National Research Council, Highway Research Board, Bulletin. Washington, D. C.
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Palaeontology (Palaeontological Association). London.
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U.S. Geological Survey, Bulletin; Circular; Coal Investigations Map; Geophysical Investigations Map; Mineral Investigations Map; Miscellaneous Investigations Map; Oil and Gas Investigations Map; Trace Elements Investigations Report; Water-Supply Paper. Washington, D. C.
Utah Geological and Mineralogical Survey, Bulletin. Salt Lake City.
Utah Geological Society, Guidebook to the Geology of Utah. Salt Lake City.
Water & Sewage Works. Chicago.
West Virginia Geological & Economic Survey, Report of Investigations. Morgantown.
Woods Hole Oceanographic Institution, [Technical Report]. Woods Hole, Massachusetts.
Yale University, Peabody Museum of Natural History, Bulletin. New Haven, Connecticut.

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GeoScience Abstracts

1. GEOLOGIC MAPS, AREAL AND REGIONAL GEOLOGY

PART 1. GEOLOGIC MAPS

See also: Areal and Regional Geology 3-2143, 3-2144, 3-2146, 3-2164, 3-2165, 3-2166; Structural Geology 3-2211; Igneous and Metamorphic Petrology 3-2358; Geohydrology 3-2385, 3-2386, 3-2389, 3-2390, 3-2393; Mineral Deposits 3-2415, 3-2419, 3-2422; Fuels 3-2431; Miscellaneous 3-2474.

Correction: GeoScience Abstracts 3-1396 in v. 3, No. 5, May 1961 should read Ohio, Div. Shore Erosion, Tech. Rept. no. 7, not Tech. Rept. no. 8.

3-2111. Canada, Geological Survey. ALBERTA AND NORTHEASTERN BRITISH COLUMBIA, SHOWING OIL AND GAS FIELDS AND OIL AND GAS DISCOVERIES. Compiled by Brian MacLean: Its: Map 1039A, 7th ed., scale 1:1,267,200, 1960.

No geology is given, but the shape and position of all known oil/or gas fields, new discoveries (information to Dec. 31, 1959), gas pipe lines (planned and constructed), oil refineries, natural gas processing plants, and known distribution of bituminous sand, plus the stratigraphic position of productive reservoirs are shown.--M. Stewart.

3-2112. Fyles, John G. SURFICIAL GEOLOGY, COURTENAY (COMOX, NELSON, NANAIMO AND NEWCASTLE DISTRICTS), VANCOUVER ISLAND, BRITISH COLUMBIA: Canada, Geol. Survey, Map 32-1960, scale 1:63,360, 1960.

Preliminary map showing the surficial geology of a section of the eastern coastal lowland of Vancouver Island, including the Comox-Courtenay agricultural area and the Comox coal field. The oldest surficial materials in the area are glacial deposits termed the Dashwood drift and succeeding sandy to clayey fluvial and marine deposits composing the Quadra sediments. These old deposits are confined to the coastal part of the area E. and N. of Courtenay. They are overlain by ground moraine and glaciofluvial deposits composing the Vashon drift. This drift, which relates to the last glaciation of the region, rests directly upon the bedrock throughout the rest of the area. The overlying Capilano sediments are "raised" or terraced marine, glaciomarine, deltaic, and fluvial deposits formed during and since glaciation. The Salish sediments, consisting of modern shore, deltaic, and fluvial deposits have accumulated since the seashore reached its present level and valleys were cut to about their present depth. Projected sections of Willemar Bluff and Komas Bluff illustrate the stratigraphic succession.--Auth.

3-2113. Quinn, Harold A. GEOLOGY, ISLAND LAKE, MANITOBA-ONTARIO: Canada, Geol. Survey, Map 26-1960, scale 1:253,440, descriptive notes, 1960, 5 refs.

The geology is that of an area of approximately 5,000 sq. mi., 70 mi. E. of Norway House and Lake Winnipeg. The oldest group, the Hayes River group, is a complex of volcanic and sedimentary rocks of Archean age. Volcanic rocks consist mainly of andesite and dacite flows. Along shear zones volcanic rocks have been altered to schists. Island Lake series overlies the Hayes River group disconformably. These younger, coarse, clastic sedimentary rocks consist of basal conglomerate grading upward into arkose and arkosic quartzite. Mixed gneisses of the next unit are mainly paragneiss, hornblende-plagioclase gneiss, amphibolite and schist; mostly altered remnants of the Hayes River group. Basic to ultrabasic intrusive rocks occur mainly as sills in or adjacent to volcanic rocks. Bodies of granite, granodiorite, and quartz manganite cut all older rocks. Dikes and sills of red pegmatite and aplite are common throughout the area. Three main easterly trending belts of sedimentary and volcanic rocks appear to be synclines or remnants of synclines. Major strike faults occur along the volcanic belt in Island Lake. Base and precious metals are found in all 3 zones. Numerous occurrences of Au and Ni are known.--M. Stewart.

3-2114. Neale, E. R. W., and others. GEOLOGY, KINGS POINT, NEWFOUNDLAND: Canada, Geol. Survey, Map 35-1960, scale 1:63,360, descriptive notes, 1960, 3 refs.

Preliminary map of a 350 sq. mi. area in the western Notre Dame region, N. of Badger on the C.N.R. line. The oldest rocks are pre-Ordovician gneisses and schists of the Fleur de Lys group. Latest recrystallization of these rocks took place in Devonian (Acadian) orogeny as shown by a 355 m.y. K/A age determination. Ordovician basic pillow lavas and associated pyroclastic rocks, graywacke, argillite, and black slate are interpreted as parts of the Baie Verte and Lush's Bight groups. Serpentinized ultrabasic rocks are located along part of the contact between the Fleur de Lys and Baie Verte groups. Middle Silurian fossils occur in a dominantly volcanic unit 5 or 6 mi. S. of Kings Point Village. Two other units that differ from the Ordovician rocks of the area by their abundance of silicic volcanic and/or terrestrial sedimentary rocks are tentatively interpreted as Ordovician. Intrusive quartz-feldspar porphyry is intimately admixed with the volcanic rocks of one of these units. It is suggested that arkosic sandstone, conglomerate, and amygdaloidal flows that form part of the Springdale group may be a facies of the fossiliferous Silurian unit. Granodiorite, quartz monzonite, syenite and granite form the major intrusive bodies of the area. A K/A date of 358 m.y. on biotite from one of the granite bodies suggests a Devonian age. Weakly consolidated red beds near Kings Point village, formerly mapped as Springdale group, are classified as Devonian or later and interpreted as postgranitic intrusion. Minor showings of asbestos, pyrite, chalcopyrite, galena, and sphalerite are noted.--E. R. W. Neale.

3-2115. Emslie, R. F. GEOLOGY, LAKE ST. JOSEPH, KENORA AND THUNDER BAY DISTRICTS, ONTARIO: Canada, Geol. Survey, Map 51-1960, scale 1:253,440, descriptive notes, 1961, 9 refs.

Geology of an area of approximately 6,000 sq. mi., N. of Port Arthur. Rocks are Precambrian. Mafic metavolcanic rocks are the oldest in the area. Some acid volcanics are interbedded with basic varieties. Siliceous metasedimentary rocks with derived schists and gneisses compose a second unit. Fe formation is common in small amounts, generally interbedded with the volcanic sequences. Foliated granodioritic rocks are widespread, and well-banded gneiss, though rare, occurs locally in this unit. Several masses of gabbro with accompanying diorite phases are present, and small gabbro sills and dikes are numerous. Porphyritic granitic rocks have large potash feldspar phenocrysts that compose more than 15% of the rock. The porphyritic rocks are predominantly massive. Massive, equigranular granite

and associated aplites and pegmatites cut all other rocks. Pickle Crow Gold Mines Ltd. is at present the only operating mine in the area. Central Patricia Gold Mines Ltd. ceased mining operations in 1951. Intensive exploratory drilling was carried out by Steep Rock Iron Mines Ltd. on their Lake St. Joseph property in 1960.--M. Stewart.

3-2116. Frankel, L. SURFICIAL GEOLOGY, MONTAGUE, KINGS AND QUEENS COUNTIES, PRINCE EDWARD ISLAND: Canada, Geol. Survey, Map 33-1960, scale 1:63,360, descriptive notes, 1961.

Surficial geology of an area of approximately 600 sq. mi. on the southeastern tip of the island, S. of Charlottetown. Bedrock consists mainly of Permo-Carboniferous sandstone and minor conglomerate. Thin beds of shale are exposed in sandstone. Pleistocene deposits of ground moraine, glaciolacustrine, and glaciofluvial deposits. Swamps, salt marshes, and shore deposits are postglacial and Recent. The structure of the area is imperfectly known because of complex cross-bedding and scarcity of rock exposure. Generalizations are as follows: a domal structure, possibly the result of salt intrusion at depth, is found at Hillsborough Bay; a cuesta is the explanation of the hills N. of Powell; Iona-Caledonia area is the center of a broad syncline; large bays also indicate breached domal structures. Filicineae, Lycopsida, Equisetales, and Pteriodospermales, and bone fragments have been found in the sedimentary rocks. Few glacial striae are preserved, and the area had extreme ice stagnation during the waning stages of the Wisconsin glaciation. Submergence is indicated by swamps etc. whereas shore features are continuously destroyed by wave and current action. The minimum age for the deglaciation is given as 6,600 $\pm$ 270 years B. P. by radiocarbon dating. --M. Stewart.

3-2117. Crowl, G.H. SURFICIAL GEOLOGY, MOUNT STEWART, KINGS AND QUEENS COUNTIES, PRINCE EDWARD ISLAND: Canada, Geol. Survey, Map 36-1960, scale 1:63,360, descriptive notes, 1960.

Preliminary geology of an area of approximately 400 sq. mi. on the N. end of the island, where the SW. corner of the map-sheet is but a few miles from Charlottetown. The Permo-Carboniferous bedrock comprises a series of sandstones, siltstones, and shales. Cross-bedding is common in the sandstone. The area was glaciated during the Wisconsin age. There is no evidence of older glaciations. About half the area is covered by ground moraine with little microrelief. It is composed of: 1) sand phase, 2) clay-sand phase, and 3) compact sand till. Ablation moraine covers a small part of the area and commonly shows a rougher topography than the ground moraine. It is developed on till that is generally loose and sandy. Stratified drift ranging from ice-contact debris to outwash features covers about one-third of the area. Glacial striae are preserved on hard sandstone. Evidence shows that the ice moved eastward in the present Gulf of St. Lawrence and westward from the center of Cape Breton Island. The area was deglaciated under conditions of ice stagnation. Glaciofluvial deposits, swamps, and shore deposits resulted.--M. Stewart.

3-2118. Crowl, G.H. SURFICIAL GEOLOGY, SOURIS, KINGS COUNTY, PRINCE EDWARD ISLAND: Canada, Geol. Survey, Map 37-1960, scale 1:63,360, descriptive notes, 1960.

Preliminary map of an area of approximately 400 sq. mi. on the northeastern tip of the island, directly E. of Charlottetown. The bedrock of Permo-Carboniferous age, exposed in many places, comprises sandstone, shale, and conglomerates. The beds are extensively cross-bedded and flat-lying. Coal plant fossils indicate a riverine or swampy depositional environment. The area was glaciated during the Wisconsin age. About three-quarters of the area is covered by ground moraine divided into: 1) sand phase, 2) clay-sand phase, and 3) compact sand till. Ablation moraine covers a small part of the area and commonly shows rougher topography since it is composed of loose, generally sandy, till. Stratified glaciofluvial deposits with eskers and kames cover about one-third of the area. The materials are well to poorly sorted. In numerous places beneath the drift, glacial striae are preserved on hard sandstone. Evidence shows that the ice moved westward from the center of Cape Breton Island, while ice in the present Gulf of St. Lawrence moved inland. Two ice ages are noted: 1) the Cape Breton ice, and 2) the New Brunswick ice. Swamps, salt marshes, and shore deposits complete the stratigraphic succession.--M. Stewart.

3-2119. MOUNT McKINLEY, ALASKA; A RECONNAISSANCE TOPOGRAPHIC MAP. Surveyed and edited by Bradford Washburn: scale 1:50,000, contour interval 100 ft., lat. 62°56'-63°15'N., long. 150°34'-151°16'W., Museum of Science, Science Park, Boston 14, Massachusetts, 1960.

The map was prepared under the auspices of the Museum of Science, Boston, Massachusetts; The Swiss Foundation for Alpine Research, Zurich; The American Academy of Arts and Sciences; and the late Dr. Alexander Hamilton Rice. Photogrammetry was by Wild Heerbrugg, Ltd., Switzerland, and cartographic art work and printing by the Swiss Federal Institute of Topography.

Glaciers and perennial snow (as of 1951) are shown in blue, rock surfaces in brown, and grass or moss in green. Relief is accentuated by plastic shading and the Swiss style of "rock drawing." Every tenth contour is shown extending through the rock areas.--A. C. Sangree.

3-2120. Lydon, Philip A., and others., comps. GEOLOGIC MAP OF CALIFORNIA: WESTWOOD SHEET: California Div. Mines, 2 sheets: geol. map, strat. nomenclature, scale 1:250,000, contour intervals 100 and 200 ft., 5 illus., 1961, 14 refs.

The seventh sheet of the O.P. Jenkins edition of the geologic map of California covers the area 40°-41°N. 120°-122°W. It indicates in color the geology of an area in northern California extending from the Nevada state line on the E. almost to the E. edge of the Sacramento Valley on the W., and from Burney and Madeline plains on the N. to the canyon of the Feather River on the S.

Thirty-five state geologic map units appear on the Westwood sheet: 10 Quaternary, 3 Pliocene, 1 each of Miocene and Oligocene, 2 Eocene, 4 undivided Tertiary, 7 Mesozoic, 5 Paleozoic, and 2 pre-Cretaceous. Metamorphic, plutonic, volcanic, and lacustrine, continental, and marine sedimentary rocks are differentiated. In addition, volcanic units are subdivided by composition.

Accompanying the map is a sheet containing a list

f the maps and reports used in the compilation, a able of stratigraphic nomenclature and lithologic haracteristics, an index map showing the U.S. Geo- gical Survey topographic maps covering the area, nd 3 photographs. An uncolored geologic map also s available.

The western half of the Westwood sheet represents ew mapping of almost the entire area of the U.S. eological Survey Lassen Peak Folio; much of the astern half of the sheet has heretofore been un- apped.--Auth.

-2121. U.S. Geological Survey. YOSEMITE VAL- EY, YOSEMITE NATIONAL PARK, MARIPOSA OUNTY, CALIFORNIA: scale 1:24,000, contour in- erval 40 ft., lat. 37°42'-37°47'05"N., long. 119°29'10"- 119°45'W., 1958, reprinted 1961.

1-2122. Friedman, S.A. GEOLOGY AND COAL DEPOSITS OF THE TERRE HAUTE AND DENNISON QUADRANGLES, VIGO COUNTY, INDIANA: U.S. Geol. Survey, Coal Inv. Map C-44, scale 1:24,000, contour interval 10 ft., lat. 39°22'30"-39°30'N., long. 87°22'30"-87°30'W., 1961.

These quadrangles cover an area of 62 sq. mi. in W.-central Indiana. The geologic map shows bedrock in green and surficial deposits in yellow orange. The map sheet also contains an index map, columnar section, and an explanatory text. Distribution, structure, and mined areas of coals; 2 cross sections; index map; and 5 tables are also included.--U.S. Geol. Survey.

3-2123. Becraft, George E., and Darrell M. Pinckney. PRELIMINARY GEOLOGIC MAP OF THE NORTHWEST QUARTER OF THE BOULDER QUADRANGLE, MONTANA: U.S. Geol. Survey, Mineral Inv. Map MF-183, scale 1:24,000, lat. 46°07'30"-46°15'N., long. 112°07'30"-112°15'W., 1961.

3-2124. Richards, Paul W., and Constance L. Nieschmidt. THE BIGHORN DOLOMITE AND CORRELATIVE FORMATIONS IN SOUTHERN MONTANA AND NORTHERN WYOMING: U.S. Geol. Survey, Oil & Gas Inv. Map OM-202, 2 sheets, scale 1 in. to approx. 12 mi., 1961.

The correlation of the Bighorn dolomite of Ordovician age in and near the Beartooth, Pryor, and Bighorn Mountains and the Absaroka Range of southern Montana and northern Wyoming with the Red River and Stony Mountain formations in southeastern Montana is illustrated by 3 cross sections of lithologic, radioactivity, or electric logs. The thicknesses of the Bighorn dolomite, the Whitewood dolomite, and the Red River and Stony Mountain formations are shown on 3 maps.--U.S. Geol. Survey.

3-2125. U.S. Geological Survey. BANDELIER NATIONAL MONUMENT AND VICINITY, NEW MEXICO: shaded relief ed., scale 1:24,000, contour interval 20 ft., lat. 35°40'-35°55'N., long. 106°07'30"-106°22'30"W., 1961.

3-2126. Bergsten, John M., and Lillian A. Heeren, comps. OIL AND GAS FIELD ATLAS OF THE FOXBURG QUADRANGLE, PENNSYLVANIA: Pennsylvania Geol. Survey, Spec. Bull. 9, 26 p., 9 col. maps, 4 pls., 1961.

Nine maps of the Foxburg quadrangle have been prepared on a scale of 1 in. to 2,000 ft. to show the oil and gas-producing areas of the quadrangle and the location of the wells that have been drilled for oil and gas. Each map represents 1/9 of the quadrangle or 5 min. of latitude and longitude. A structure map has also been drawn to show the structure on the top of the Venango first sand [Devonian] by means of 25-ft. contours. Other plates are: a composite section showing the producing oil and gas sands and other lithologic units, a cross section of wells (gamma logs, sample descriptions) along the eastern border of the quadrangle, and a cross section of wells (gamma logs) along the western border of the quadrangle. The datum line for the logs is the Venango first sand. Also included is a table consisting of selected driller's records of wells completed in the Foxburg quadrangle. The maps, composite section, cross sections, and well records are published in advance of a complete report on the oil and gas resources of the Foxburg quadrangle.--Auth.

3-2127. Bromery, Randolph W., and others. AEROMAGNETIC MAP OF THE COLUMBIA EAST QUADRANGLE, LANCASTER COUNTY, PENNSYLVANIA: U.S. Geol. Survey, Geophys. Inv. Map GP-258, scale 1:24,000, contour interval 25 gammas, lat. 40°-40°07'30"N., long. 76°22'30"-76°30'W., 1961.

3-2128. Bromery, Randolph W., and others. AEROMAGNETIC MAP OF THE EPHRATA QUADRANGLE, LANCASTER COUNTY, PENNSYLVANIA: U.S. Geol. Survey, Geophys. Inv. Map GP-241, scale 1:24,000, contour interval 50 gammas, lat. 40°07'30"-40°15'N., long. 76°07'30"-76°15'W., 1961.

3-2129. Bromery, Randolph W., and others. AEROMAGNETIC MAP OF THE GAP QUADRANGLE, LANCASTER COUNTY, PENNSYLVANIA: U.S. Geol. Survey, Geophys. Inv. Map GP-245, scale 1:24,000, contour interval 50 gammas, lat. 39°52'30"-40°N., long. 76°-76°07'30"W., 1961.

3-2130. Bromery, Randolph W., and others. AEROMAGNETIC MAP OF THE LANCASTER QUADRANGLE, LANCASTER COUNTY, PENNSYLVANIA: U.S. Geol. Survey, Geophys. Inv. Map GP-259, scale 1:24,000, contour intervals 25 and 125 gammas, lat. 40°-40°07'30"N., long. 76°15'-76°22'30"W., 1961.

3-2131. Bromery, Randolph W., and others. AEROMAGNETIC MAP OF THE LEBANON QUADRANGLE, LEBANON COUNTY, PENNSYLVANIA: U.S. Geol. Survey, Geophys. Inv. Map GP-254, scale 1:24,000, contour interval 50 gammas, lat. 40°15'-40°22'30"N., long. 76°22'30"-76°30'W., 1961.

3-2132. Bromery, Randolph W., and others. AEROMAGNETIC MAP OF THE LEOLA QUADRANGLE, LANCASTER COUNTY, PENNSYLVANIA: U.S. Geol. Survey, Geophys. Inv. Map GP-243, scale 1:24,000, contour interval 50 gammas, lat. 40°-40°07'30"N., long. 76°07'30"-76°15'W., 1961.

3-2133. Bromery, Randolph W., and others. AEROMAGNETIC MAP OF THE LITITZ QUADRANGLE, LANCASTER AND LEBANON COUNTIES, PENNSYLVANIA: U.S. Geol. Survey, Geophys. Inv. Map GP-257, scale 1:24,000, contour interval 50 gammas, lat. 40°07'30"-40°15'N., long. 76°15'-76°22'30"W., 1961.

3-2134. Bromery, Randolph W., and others. AEROMAGNETIC MAP OF THE MANHEIM QUADRANGLE, LANCASTER AND LEBANON COUNTIES, PENNSYLVANIA: U.S. Geol. Survey, Geophys. Inv. Map GP-256, scale 1:24,000, contour interval 50 gammas, lat. 40°07'30"-40°15'N., long. 76°22'30"-76°30'W., 1961.

3-2135. Bromery, Randolph W., and others. AEROMAGNETIC MAP OF THE NEW HOLLAND QUADRANGLE, LANCASTER COUNTY, PENNSYLVANIA: U.S. Geol. Survey, Geophys. Inv. Map GP-244, scale 1:24,000, contour interval 50 gammas, lat. 40°-40°07'30"N., long. 76°-76°07'30"W., 1961.

3-2136. Bromery, Randolph W., and others. AEROMAGNETIC MAP OF THE RICHLAND QUADRANGLE, LEBANON AND LANCASTER COUNTIES, PENNSYLVANIA: U.S. Geol. Survey, Geophys. Inv. Map GP-255, scale 1:24,000, contour interval 50 gammas, lat. 40°15'-40°22'30"N., long. 76°15'-76°22'30"W., 1961.

3-2137. Bromery, Randolph W., and others. AEROMAGNETIC MAP OF THE SINKING SPRING QUADRANGLE, BERKS AND LANCASTER COUNTIES, PENNSYLVANIA: U.S. Geol. Survey, Geophys. Inv. Map GP-240, scale 1:24,000, contour interval 50 gammas, lat. 40°15'-40°22'30"N., long. 76°-76°07'30"W., 1961.

3-2138. Bromery, Randolph W., and others. AEROMAGNETIC MAP OF THE TERRE HILL QUADRANGLE, LANCASTER AND BERKS COUNTIES, PENNSYLVANIA: U.S. Geol. Survey, Geophys. Map GP-242, scale 1:24,000, contour interval 50 gammas, lat. 40°07'30"-40°15'N., long. 76°-76°07'30"W., 1961.

3-2139. Bromery, Randolph W., and others. AEROMAGNETIC MAP OF THE WOMELSDORF QUADRANGLE, BERKS, LEBANON, AND LANCASTER COUNTIES, PENNSYLVANIA: U.S. Geol. Survey, Geophys. Inv. Map GP-239, scale 1:24,000, contour interval 50 gammas, lat. 40°15'-40°22'30"N., long. 76°07'30"-76°15'W., 1961.

3-2140. Hansen, Wallace R. GEOLOGIC MAP OF THE WILLOW CREEK BUTTE QUADRANGLE, UTAH-COLORADO: U.S. Geol. Survey, Misc. Inv. Map I-322, scale 1:24,000, lat. 40°52'30"-41°N., long. 109°-109°07'30"W., 1961.

3-2141. Berryhill, Henry L., Jr., and Lynn Glover, 3d. GEOLOGY OF THE CAYEY QUADRANGLE, PUERTO RICO: U.S. Geol. Survey, Misc. Inv. Map I-319, scale 1:20,000, lat. 18°-18°07'30"N., long. 66°07'30"-66°15'W., 1960, pub. 1961.

Volcanic and marine sedimentary rocks and lava flows of Cretaceous age have been intruded by small bodies of dioritic and andesitic rocks. The rocks have been folded into a gentle westward plunging anticline, which has been intensely faulted. Pb, Zn, Cu, Ag, and Au have been mined in small quantities. Large quantities of limestone are available in the area.--U.S. Geol. Survey.

3-2142. Pease, Maurice H., Jr., and Reginald P. Briggs. GEOLOGY OF THE COMERIO QUADRANGLE, PUERTO RICO: U.S. Geol. Survey, Misc. Inv. Map I-320, scale 1:20,000, lat. 18°07'30"-18°15'N., long. 66°07'30"-66°15'W., 1960, pub. 1961.

A sequence of volcanic sedimentary rocks and lavas of Cretaceous age and chiefly of marine origin is exposed. A broad intensely faulted anticline plunges northwestward across the central part of the quadrangle, and a westward trending zone of sheared rocks is exposed in the northern part of the quadrangle. Moderate quantities of pyrophyllite, alunite, and kaolinite clay occur in hydrothermally altered rocks. Disseminated Cu minerals are found in the northwestern part of the quadrangle.--U.S. Geol. Survey.

PART 2. AREAL AND REGIONAL GEOLOGY

See also: Geohydrology 3-2395; Mineral Deposits 3-2415; Engineering Geology 3-2461.

3-2143. Karrow, Paul F. PLEISTOCENE GEOLOGY OF THE GALT MAP-AREA: Ontario, Dept. Mines, Geol. Circ. no. 9, 7 p., 2 maps incl. col. map (in pocket), scale 1:63,360, 1961, 3 refs.

The Galt map-area, southern Ontario, is located in the peninsula between Lake Huron and Lake Ontario. Field work consisted of the examination of cuts, soil augering, the digging of test pits, and the location of water wells for information on the thickness of overburden and nature of the bedrock surface.

The formations underlying the area are of Silurian age. They consist of the Lockport-Amabel dolomite, the Guelph dolomite, and the Salina formation. The Salina is not exposed in the area. In the E., drift is thin, and bedrock outcrops are extensive, revealing a gently-sloping bedrock surface. In the W., drift is as thick as 350 ft., and an irregular bedrock surface is indicated.

The Pleistocene succession is best exposed along the Grand River near Kitchener. Three ice advances deposited a lower sandy till, varved clays much reworked to form a middle clay till, ablation deposits of sand and gravel, and an upper sandy till called the Wentworth till. A small part of the SE. corner is underlain by gray silty Halton till. Large moraines and extensive outwash deposits were laid down in much of the map-area during the retreat of the ice.

Glacial lakes of the Lake Erie basin left shorelines at 905 ft. and several lower elevations. Laminated lacustrine sands, silts, and clays form a lake plain in the southern part of the area.--Auth.

3-2144. Moorhouse, W. W. GUNFLINT IRON RANGE IN THE VICINITY OF PORT ARTHUR: Ontario Dept. Mines, Ann. Rept., v. 69, pt. 7, p. 1-40, 19 illus., 9 figs., 8 maps (in pocket), scale 1:31,680, table, 1960, refs.

The gently-dipping Precambrian Animikie rocks of the Port Arthur region unconformably overlie the greenstones, tuffs, graywackes, and granites of the Archean. The Gunflint Fe formation, the lower part of the Animikie, is separated into 3 subdivisions on the accompanying maps. The lower Gunflint, beginning locally with gravelly conglomerate, consists of lenticular beds of ferruginous carbonate, chert, jasper, algal cherts, hematite, and magnetite taconites, and W. of the Kaministikwia River, silicate taconite. The lower Gunflint is overlain by the argillite-tuff unit, of black and gray argillite, tuff, carbonate, and chert. The upper Gunflint, in the vicinity of Loon Lake, is thin-bedded chert and ferruginous carbonate. Similar but thicker beds outcrop along the Current River. W. of Port Arthur the upper Gun-

flint is largely chert, jasper, and silicate taconite.

The Gunflint is overlain by the Rove formation consisting of argillite, graywacke, and thin carbonate layers. Calcareous concretions are locally abundant. Overlying the Animikie with unconformity but with small angular discordance, is the Keweenawan Sibley formation, consisting of conglomerate, sandstone, limestone, and silty red carbonate rocks. All these rocks are intruded by sheets of diabase, which are responsible for the cuestas, buttes, and mesas that characterize the landscape around Port Arthur and Fort William.

Brief summaries are given of the mineralogy, texture, metamorphism, sedimentary facies and chemical composition of the Gunflint. The prospects for the development of an Fe mining industry in the area mapped are not promising at the present time.--Auth.

3-2145. Goodwin, A. M. GUNFLINT IRON FORMATION OF THE WHITEFISH LAKE AREA: Ontario Dept. Mines, Ann. Rept., v. 69, pt. 7, p. 41-63, 7 illus., map, 8 tables, 1960, refs.

This report deals with the Precambrian Fe-bearing formation occurring in Jean, Hardwick, Strange, Lismore, and the S. half of Lybster townships, District of Thunder Bay, Ontario. Attention is directed to the stratigraphy and Fe ore potentialities. The Fe formation is a sequence of sedimentary and, locally, volcanic rocks, with a total thickness of about 475 ft. The formation is characterized by an unusually high Fe content, as well as by a variety of textures, the granular texture of the taconite rock being most distinctive. The formation is divided into lower and upper cycles. Each cycle contains a sequence of members, most of which are common to both. The uppermost member, a limestone bed, is unique to the formation and marks the top of the Fe-bearing rocks. Each of the members is described.

The average chemical composition of the Fe-bearing rocks of the Gunflint Fe formation within the map area, the apparent lack of oxidation and leaching, and the negative results of magnetic concentration tests, are not encouraging for the discovery of ore material within the map-area. The economic future of the Fe-bearing rocks appears to depend upon a process that will produce a commercial concentrate. The rapid development of beneficiating methods suggests that future improvements might be sufficient to bring the Fe-bearing rocks of the Gunflint Fe formation within the range of commercial exploitation.--A. C. Sangree.

3-2146. Thomson, James E. MACLENNAN AND SCADDING TOWNSHIPS: Ontario, Dept. Mines, Geol. Rept. no. 2, 34 p., illus., Map 2009 (in pocket), scale 1:31,680, 3 charts (in pocket), 1961, refs.

A detailed restudy of part of the eastern Ni range at Sudbury and the country immediately E. of it around the S. end of Lake Wanapitei. Most of the southern part of the map-area is underlain by a volcanic group and a sedimentary (Sudbury) group of pre-Huronian age. These rocks are highly metamorphosed and considerably granitized in the country lying S. and W. of Wanapitei Lake. The Mississagi formation of Huronian age lies with great erosional and angular unconformity upon a number of different pre-Huronian rock formations. At a few places around Lake Wanapitei the basal Mississagi beds consist of radioactive conglomerate. In Scadding township the Gowganda formation lies unconformably upon the Mississagi formation.

The outer contact of the Sudbury norite in Maclennan township dips steeply basinward and is quite irregular in outline. The contact zone between the norite and micropegmatite (granophyre) is well-defined and is only a few feet thick. Dikes, sills, and irregular bodies of gabbro (Nipissing diabase) are found to have intruded pre-Huronian and Huronian rocks and have much breccia of the Sudbury type associated with them. The Grenville Front crosses the extreme SE. corner of Scadding township.

The pre-Huronian formations are greatly deformed. The Huronian strata are relatively flat-lying except in the vicinity of faults and gabbroic intrusives where they have a steep dip. Several faults occur in the area, and 2 of these (Airport-Ess Creek, and MacLaren Lake) are part of regional fault systems.

Ni-Cu deposits of the Sudbury type occur along and near the norite contact and have been extensively developed by drilling. The only mineral production of the area has come from the Nickel Rim mine, which produced Ni-Cu concentrates valued at slightly more than $10,000,000 from 1952 to 1958. A few small Au and Au-Cu showings in the area have been developed, and low-grade uraniferous conglomerate at the base of the Huronian system has been investigated.--Auth.

3-2147. Rice, Salem J. GEOLOGIC SKETCH OF THE NORTHERN COAST RANGES: California, Div. Mines, Mineral Inf. Service, v. 14, no. 1, p. 1-9, 4 illus., map, Jan. 1961, 16 refs.

A brief description of the geology of the northern Coast Ranges of California, a mountainous region of approximately 13,000 sq. mi. lying NW. of San Francisco.

The northern Coast Ranges are largely underlain by the Franciscan formation, a thick geosynclinal sequence composed predominantly of graywacke, with subordinate amounts of shale, conglomerate, chert, greenstone, and limestone. Peridotite, serpentine, and gabbro are intrusive into the Franciscan, and locally the sedimentary and volcanic rocks of the formation are metamorphosed to glaucophane schist. The Franciscan formation ranges in age from latest Late Jurassic to early Late Cretaceous. Phyllite, slate, and mica schist that occur in 2 large areas may represent an older geological unit.

The Cenozoic history of the region is largely one of emergence and erosion, although some restricted embayments, seaways, and basins accumulated thick deposits of marine and nonmarine sediments during this interval. Late Cenozoic volcanic activity in the southern part of the region resulted in eruption of lava and pyroclastic detritus that are several thousand feet thick in the Sonoma Mountains and Clear Lake areas.

Structural relationships are complex within and bordering the northern Coast Ranges, requiring much more study than is now available for detailed interpretation. However, folding and faulting of deposits of various ages, apparently progressively more intense in the older formations, attest to several periods of tectonic activity.

Mineral commodities that have been produced from the region include Hg, Mn, chromite, Cu, asbestos, clay, magnesite, perlite, sand and gravel, expansible shale, natural gas, and coal. One of the most interesting recent developments is the utilization of natural super-heated steam in Sonoma County for production of electrical power.--Auth.

3-2148. Weimer, Robert J., and John D. Haun, eds. GUIDE TO THE GEOLOGY OF COLORADO: 310 p., illus., maps, charts, secs., diags., Denver, Geological Society of America, Rocky Mountain Association of Geologists, and Colorado Scientific Society, 1960, refs.

This book was prepared for the 1960 annual meeting of the Geological Society of America and associated societies, and the 1961 annual meeting of the American Association of Petroleum Geologists. The 12 general papers contained in this guidebook cover much of the geology of the state and are abstracted separately below. The road logs cover only the areas selected for field study during the time preceding and following the meetings. A companion volume, "Road Logs of Colorado," supplements this book by providing road logs for the major highways of the remainder of the state (see abstract immediately following those for this guidebook). The field trips in this guidebook are as follows:

Geology of West-Central Colorado, by S. W. Lohman.
- Mancos Shale and Mesaverde Group of Palisade Area, by Robert G. Young.
- Colorado National Monument and Adjacent Areas, by S. W. Lohman.

Geology of South-Central Colorado, by John Chronic.
- Brief Description of the Igneous Bodies of the Raton Mesa Region, South-Central Colorado, by Ross B. Johnson.
- Permo-Pennsylvanian Stratigraphy in the Sangre De Cristo Mountains, Colorado, by Dudley W. Bolyard.
- Great Sand Dunes of Colorado, by George P. Merk.
- Geology near Orient Mine, Sangre de Cristo Mountains, by Linus R. Litsey.

Tectonics and Economic Geology of Central Colorado, by Robert M. Hutchinson.
- Kokomo Mining District, by A. H. Koschmann.
- Tectonic Relationships of Central Colorado, by Peter C. Badgley.
- Structure and Petrology of North End of Pikes Peak Batholith, Colorado, by Robert M. Hutchinson.
- Precambrian Rocks and Structure of the Platte Canyon and Kassler Quadrangles, Colorado, by Warren L. Peterson and Glenn R. Scott.
- Gravity Map of the Hartsel Area, South Park, Colorado, by P. A. Rodgers.
- Cripple Creek District, by A. H. Koschmann.
- Geologic Formations and Structure of Colorado Springs Area, Colorado, by L. Trowbridge Grose.
- Placers of Summit and Park Counties, Colorado, by Ben Parker, Jr.

Quaternary Geology of the Front Range and Adjacent Plains, by W. C. Bradley and Glenn R. Scott.
- First Day - Pleistocene Geology of the Eastern Slope of Rocky Mountain National Park, Colorado Front Range, by Gerald M. Richmond and W. C. Bradley.
- Second Day - Surficial Geology of the Kassler and Littleton Quadrangles near Denver, Colorado, by Glenn R. Scott.
- Quaternary Sequence East of the Front Range near Denver, Colorado, by Glenn R. Scott.

Geology of the Northern Front Range - Laramie Range, Colorado and Wyoming, by D. W. Boyd.
- Summary of Cenozoic History, Southern Laramie Range, Wyoming and Colorado, by Fred E. Moore.
- Laramie Anorthosite, by M. A. Klugman.
- Cross-Lamination and Local Deformation in the Casper Sandstone, Southeast Wyoming, by S. H. Knight.
- Dakota Group in Northern Front Range Area, by Karl M. Waage and Don L. Eicher.

Field trip to Climax, Colorado (no road log)
- Geology of the Climax Molybdenite Deposit: A Progress Report, by Stewart R. Wallace, and others.

Stratigraphy of Colorado Springs-Canyon City Area, by H. W. Oborne and W. A. Fischer.

Engineering Geology-Distribution System of the Colorado-Big Thompson Project, by Mansfield Merriman.

Precambrian Geology of the Idaho Springs-Central City Area, Colorado, by D. M. Sheridan, P. K. Sims, and J. E. Harrison.
- Geology of the Central City-Idaho Springs Area, Front Range, Colorado, by P. K. Sims.

Fossil Vertebrates and Sedimentary Rocks of the Front Range Foothills, Colorado, by G. Edward Lewis.

Geology of the Front Range Foothills, Boulder-Lyons-Loveland Area, Colorado, by W. O. Thompson and T. R. Walker.

Geology of Mountain Front West of Denver, by John D. Haun.

3-2149. Curtis, Bruce F. MAJOR GEOLOGIC FEATURES OF COLORADO (In: Weimer, Robert J., and John D. Haun, eds. Guide to the Geology of Colorado: p. 1-8, 2 maps, Denver, 1960) 7 refs.

A brief description of physiography, stratigraphy, structure, and mineral resources of Colorado. The Great Plains, which constitute the eastern 40% of the state, are underlain by the Denver basin and its bordering broad uplifts. Mesozoic and Cenozoic sedimentary rocks lie at the surface.

The central part of Colorado is dominated by high northerly-trending anticlinal mountain chains separated by topographic and structural basins called parks. The Precambrian crystalline cores of the ranges are flanked in many places by early Paleozoic carbonate and clastic sediments, and by late Paleozoic coarse clastics which reflect severe Pennsylvanian tectonism. Mesozoic and Cenozoic sedimentary rocks are thick and widespread in central and western Colorado.

Western Colorado contains several mountain ranges of anticlinal uplifts, mountains carved from Cenozoic volcanics, and high plateaus in structural basins and on uplifts.

Oil and gas, produced chiefly from Permo-Pennsylvanian and Cretaceous rocks, rank first among Colorado's mineral products. Mo deposits are second in economic importance, U and V third, and coal fourth. Other metallic minerals are still mined at a few places in the famous NE.-trending central mineral belt of the mountain areas.--Auth.

3-2150. Qureshy, M. N. AIRY-HEISKANEN ANOMALY MAP OF COLORADO (In: Weimer, Robert J., and John D. Haun, eds. Guide to the Geology of Colorado: p. 8-9, map, Denver, 1960)

The map presented shows Airy-Heiskanen anomalies computed at some 1,600 points from data supplied by Ralph C. Holmer. The anomalies computed are for sea level crustal thickness of 30 km., and a density difference of 0.6 gm/cm.^{3} between the crust (d = 2.67 gm./cm.^{3}), and subcrust (d = 3.27 gm./cm.^{3}). The anomalies in eastern Colorado are corrected for the sediments of Denver-Julesburg basin also. The contour interval on the map is 5 and 10 milligals.

The average anomaly in the state appears to be fairly close to zero. This is considered to show validity of this isostatic system in Colorado on a large scale only. Rather large anomalies of the order of ± 40 milligals are noticed in some areas. These are interpreted to be caused by variations in crustal thicknesses. This interpretation is utilized in computing the thickness of the earth's crust in a few selected areas.

These calculated values show a variation of the order of ± 20 km. in the crustal thicknesses in Colorado. Relatively low values result over the Front Range (Golden, 38 km.), and Uncompahgre uplift (Montrose, 36 km.); but the values are high over the Colorado mineral belt (Boulder, 46 km., Leadville, 51 km.).--Auth.

3-2151. Berg, Robert E. CAMBRIAN AND ORDOVICIAN HISTORY OF COLORADO (In: Weimer, Robert J., and John D. Haun, eds. Guide to the Geology of Colorado: p. 10-17, 2 maps, 2 secs., Denver, 1960) 30 refs.

Lowermost Paleozoic rocks are distributed widely in Colorado, both in the central outcrop area and in the subsurface, but stratigraphic details are not known completely. Limited lithologic and faunal data which are available show that the seas advanced into Colorado from both E. and W., and that transgression began in late Middle Cambrian time in the W. and continued uninterrupted into Early Ordovician time. Transgression from the E. probably began during the Late Cambrian. However, in central Colorado, transgression was generally southward onto the old Sierra Grande positive area as shown by the overlap of the Upper Cambrian Sawatch sandstone by the Lower Ordovician Manitou dolomite, and by the succeeding overlap of the Manitou by the Middle Ordovician Harding sandstone, and Upper Ordovician Fremont dolomite. Furthermore, age relationships suggest that southward transgression was interrupted occasionally by short periods of emergence. Therefore, the Sierra Granda uplift was a dominant early Paleozoic feature that can be partially defined areally, whereas the early Paleozoic extent of the Sioux uplift in northern Colorado is not known, for the distribution of older Paleozoic rocks around its flanks is largely the result of pre-Mississippian uplift and erosion.--Auth.

3-2152. Rothrock, David P. DEVONIAN AND MISSISSIPPIAN SYSTEMS IN COLORADO (In: Weimer, Robert J., and John D. Haun, eds. Guide to the Geology of Colorado: p. 17-22, 2 maps, sec., Denver, 1960) 17 refs.

This paper is designed to acquaint visiting geologists with some stratigraphic aspects of the Devonian and Mississippian rocks of Colorado. Short descriptions of the various lithologies are given for the eastern, central, NW., and SW. parts of the state. Devonian facies receive general description and correlation comment. Formation correlations are indicated on the cross section and discussed in the text. Current usage of such names as "Leadville," "Madison," and "Redwall," are shown to be vague and even misleading. Adoption of Mississippian divisions A, B, C, and D is recommended. In western Colorado, rocks of the 2 systems are petroliferous. Lack of commercial production at the time of writing (Dec. 1959) is attributed to insufficient drilling.--Auth.

3-2153. Mallory, William Wyman. OUTLINE OF PENNSYLVANIAN STRATIGRAPHY OF COLORADO (In: Weimer, Robert J., and John D. Haun, eds. Guide to the Geology of Colorado: p. 23-33, 3 illus., 6 maps, 3 secs., Denver, 1960) 40 refs.

Gentle epeirogeny in early and middle Paleozoic time was replaced by vigorous arching of the NW.-trending Ancestral Rockies in Pennsylvanian time. The major positive elements of this range, the Uncompahgre and Front Range uplifts were accompanied by 3 subsiding marine basins. In contrast to Paleozoic strata, Pennsylvanian rocks exhibit extreme local variation in thickness and lithology.

Three maps indicate paleogeography, areal distribution, and dominant lithologies for Morrow-Atoka, Des Moines, and Missouri-Virgil times.

Carbonate rocks in the lower part of the Hermosa formation in the Paradox basin are of Morrow and Atoka age; dark shale and thin dark limestones compose the Belden shale in central Colorado; arkosic conglomerate of the Fountain formation fringes the eastern margin of the Front Range uplift and grades E. into mixed lithologies containing glauconite.

Tectonic activity reached a peak in Des Moines time. In southwestern Colorado a thick semi-lens of salt fringed with anhydrite comprises the Paradox member of the Hermosa. Coarse arkosic clastics of the Minturn formation in central Colorado grade NW. into evaporite and carbonate of the Morgan formation. Abundant shoreline conglomerate of the Fountain formation grades eastward into a mixed lithologic sequence in the Denver basin.

Thick limestone of the upper part of the Hermosa formation in southwestern Colorado is of Missouri and Virgil age. Red detrital rocks of approximately equivalent age in central Colorado compose the Sangre de Cristo and Maroon formations, which grade NW. into the Weber sandstone. Limestone with minor clastics in NE. Colorado grades into red beds in southeastern Colorado.--Auth.

3-2154. Maughan, Edwin K., and Richard F. Wilson. PENNSYLVANIAN AND PERMIAN STRATA IN SOUTHERN WYOMING AND NORTHERN COLORADO (In: Weimer, Robert J., and John D. Haun, eds. Guide to the Geology of Colorado: p. 34-42, illus., map, 2 secs., table, Denver, 1960) 21 refs.

Detailed stratigraphic field studies of late Paleozoic strata along the eastern flank of the Front and Laramie ranges and in the Laramie basin indicate: 1) middle and lower parts of the Fountain formation in Colorado grade laterally into Pennsylvanian parts of the Casper formation in Wyoming; 2) unconformably above, the uppermost beds of the Fountain intertongue with the Ingleside formation and equivalent strata of the Casper formation of Early Permian age; 3) the Lyons sandstone intertongues with the lower part of the Satanka formation.

The Fountain formation is composed mainly of arkose probably deposited on alluvial plains. Lithic differences permit separation of the Fountain into an upper and lower part. Successively lower strata of the Fountain intertongue with marine rocks composed dominantly of interbedded sandstone and limestone assigned to the Ingleside formation N. of Lyons, Colorado, and to the Casper formation northeastward from the Laramie basin in Wyoming.

The Ingleside formation contains Lower Permian fusulinids and correlates with the upper, Permian, part of the Casper formation. These Lower Permian strata rest unconformably on parts of the Fountain

or Casper formations dated, on the basis of fusulinids, as Virgil to Des Moines or possibly Atoka in age. In the southern Laramie basin these Lower Permian rocks are mostly cross-bedded sandstone of probable dune and beach origin.

Horizontally stratified red beds of the Satanka formation, probably deposited in lagoons, estuaries, or tidal flats, overlie the Ingleside and Casper formations. These rocks intertongue with the Lyons sandstone near Lyons, Colorado, and with an unnamed sandstone previously believed part of the Casper formation in the southern Laramie basin. These sandstone units probably formed as dunes associated with beaches.--Auth.

3-2155. Oriel, Steven S., and Lawrence C. Craig. LOWER MESOZOIC ROCKS IN COLORADO (In: Weimer, Robert J., and John D. Haun, eds. Guide to the Geology of Colorado: p. 43-58, 6 maps, chart, table, Denver, 1960) 92 refs.

Triassic and Jurassic rocks in Colorado have been assigned, partly because of regional facies relations, to some 30 rock-stratigraphic units.

Regional thickness and lithofacies maps indicate that tectonic elements dominant in Colorado during late Paleozoic time continued to influence sedimentation during the early Mesozoic. These consisted mainly of the ancestral Uncompahgre highland and the ancestral Rocky Mountains.

During early Triassic time the region was tectonically quiescent, the highlands were probably low in relief, and deposits in adjoining basins were relatively fine-grained and regularly bedded. In late Triassic time, however, widely distributed, irregular orogenic pulses, and increased relief along the highlands, resulted in deposits characterized by irregularity of bedding and many coarse-textured beds and lenses. A large basin in the Four Corners region was the site of dune sand accumulation at the end of the period.

Sediments deposited during the Jurassic period encroached upon the highlands. After deposition of the mainly eolian Entrada sandstone, marine transgression from the NW. and N. during middle late Jurassic time resulted in deposition of normal marine sediments and in widespread precipitation of gypsum in lagoons and shallow, restricted basins. The persistent positive elements were almost entirely buried near the end of Jurassic time by alluvial and lacustrine deposits of the Morrison formation; abundant conglomerate beds and volcanic detritus, however, are evidence of tectonism and volcanism in surrounding regions, principally to the W. and S.--L. C. Craig.

3-2156. Haun, John D., and Robert J. Weimer. CRETACEOUS STRATIGRAPHY OF COLORADO (In: Weimer, Robert J., and John D. Haun, eds. Guide to the Geology of Colorado: p. 58-65, 9 maps, 3 secs., table, Denver, 1960) 21 refs.

Clastic sediments dominate the Cretaceous strata of Colorado, and in the NW. part of the state they are more than 12,000 ft. thick. Marine sedimentation was initiated in a seaway that transgressed across Colorado from N. to S. The sea withdrew in an easterly or northerly direction, but embayments remained that extended far to the W. Cretaceous sediments have been preserved in structural basins, and the problem of correlating between basins has required faunal study as well as regional isopachous and lithofacies work.

The Dakota group is composed of transgressive marine and nonmarine clastics that become younger from N. to S. The thickness of Lower Cretaceous rocks varies from over 500 ft. in NE. Colorado to less than 200 ft. in the W. and SW. The top of the Mowry shale, where present, defines the Upper Cretaceous-Lower Cretaceous boundary. The Mowry overlies the Dakota group and is present throughout northern and central Colorado, but to the S., it interfingers with the upper part of the Dakota group.

The Upper Cretaceous marine Benton group, Niobrara limestone, and Pierre shale to the E. were deposited contemporaneously with the marine Mancos shale, the nonmarine Mesaverde group, the marine Lewis shale, and the nonmarine Lance formation to the W. The eastern regression of the strand was periodically broken by sharp transgressions resulting in the intertonguing of gray marine shale, tan massive transitional sandstone and nonmarine coal-bearing gray clay and tan lenticular sandstone. Time lines have been established throughout the marine rocks. The "Mesaverde" and "Lewis" formations of NW. Colorado are younger and are not lithogenetically related to the type Mesaverde and type Lewis of SW. Colorado. Tertiary rocks rest unconformably on Campanian and older rocks in central and SW. Colorado and on Danian(?) and Maestrichtian in NW. and E. Colorado.--J. D. Haun.

3-2157. Hutchinson, R. M. STRUCTURE AND PETROLOGY OF NORTH END OF PIKES PEAK BATHOLITH, COLORADO (In: Weimer, Robert J., and John D. Haun, eds. Guide to the Geology of Colorado: p. 170-180, 2 maps, 4 diags., 3 pls. incl. fold. map, Denver, 1960) 11 refs.

Primary structural trends within the batholith are consistent with formation by upward movement of magma. Structures consistent with outward expansion effected by the batholith occur in metamorphic wall rocks. K-Ar isotope ages of the granite give 1,080-1,050 million years, and spatial relations indicate the batholith has mesozonal type emplacement features. Precambrian igneous activity, so far determined, took place during 2 periods, 1,080-1,050 million years (Pikes Peak granites) and 1,240-1,300 million years (Indian Creek plutons and Kenosha batholithic rocks). The former are hornblende-bearing biotite granites, and the latter are muscovite-bearing biotite granites.

Within 400 sq. mi. mapped rock types are alaskite, leucogranite, granite, quartz monzonite, granodiorite, granitic to quartz monzonitic aplites, porphyritic aplites, and granite porphyry. Granodiorite zones are derived, in part, from both metasomatic and igneous processes, but relative quantities of each have been finally estimated. Metasomatic granodiorite appears to be subordinate in amount.

Positive Airy-Heiskanen gravity anomalies exceeding +35 milligals exist over Pikes Peak batholithic tract. Selective refusion (melting) of random rock material at depth could have produced the granitic magma and also left a concentration of higher density resistates below. This combined with active, very deep-seated erosion of the batholithic tract during the Precambrian might have produced a positive anomaly by the end of Precambrian time. Post-Precambrian orogeny and erosion served to further accentuate the inherited positive anomaly.--Auth.

3-2158. Peterson, Warren L., and Glenn R. Scott. PRECAMBRIAN ROCKS AND STRUCTURE OF THE PLATTE CANYON AND KASSLER QUADRANGLES, COLORADO (In: Weimer, Robert J., and John D.

Haun, eds. Guide to the Geology of Colorado: p. 181-183, Denver, 1960) 9 refs.

The Platte Canyon and Kassler quadrangles are at the eastern edge of the Front Range along the South Platte River, 15 mi. S. of Denver.

The southern parts of the Platte Canyon and Kassler quadrangles include the northeastern margin of a large batholith of Pikes Peak granite. The central and northern parts of the quadrangles are predominantly underlain by metamorphic rocks which strike NW. and dip NE. The margin of the batholith is outward dipping and is discordant to the metamorphic rocks at a small angle.

Metamorphic and igneous rocks that occur in the Platte Canyon and Kassler quadrangles are similar to rocks found elsewhere in the Front Range. For descriptive purposes they can be divided into 3 categories: 1) metasedimentary rocks, 2) migmatite and granite gneisses, and 3) intrusive rocks.

The geologic history of the area is summarized:

1) Metamorphism of Precambrian sediments to form the metasedimentary rocks.

2) Granitization and folding of the metasedimentary rocks, followed by intrusion of the gneissic granite, quartz diorite, and toward the end of the deformation by intrusion of biotite-muscovite granite.

3) Intrusion of the Pikes Peak granite.

4) Probable uplift, and erosion of many thousands of feet of overlying rock.

5) Precambrian faulting.

6) Reopening of Precambrian faults, and emplacement of sandstone dikes during Cambrian time.

7) Pennsylvanian orogeny.

8) Laramide orogeny. Emplacement and brecciation of Tertiary dikes. Effects of the Precambrian, Pennsylvanian, and Laramide faulting generally cannot be separated.--From auth., p. 181, 183.

3-2159. Scott, Glenn R. QUATERNARY SEQUENCE EAST OF THE FRONT RANGE NEAR DENVER, COLORADO (In: Weimer, Robert J., and John D. Haun, eds. Guide to the Geology of Colorado: p. 206-211, 2 maps, 2 charts, sec., Denver, 1960) 11 refs.

This paper is based on detailed mapping of the surficial deposits of the Kassler and Littleton quadrangles, which lie along the E. flank of the Front Range about 15 mi. S. of Denver.

The Quaternary surficial deposits along the E. edge of the Front Range fall into 4 categories: alluvium, wind-blown sand and loess, bog deposits, and landslides. Together they cover about 1/2 of the hogback area and nearly all of the area E. of the hogbacks. Soil sequence, geomorphology, and stratigraphy of the area are discussed.

The Quaternary deposits are the result of repetitive physical processes controlled by cyclic changes in climate. The number and intensity of the climatic cycles can best be determined from alluvial deposits because alluvium is deposited during every cycle and generally is well preserved. A record of 8 completed geomorphic cycles and 1 cycle, historic valley cutting, still in progress is shown. As a result of the climatic changes, the general effect of each geomorphic cycle is to force the streams down to a lower stable base level where they stay until renewed climatic changes generate the next geomorphic cycle. Each geomorphic cycle is made up of 5 processes, in chronologic order: 1) downward stream cutting, 2) sideward stream cutting, 3) alluviation, 4) wind erosion and deposition, and 5) soil formation. These physical processes are closely related to changes in temperature, precipitation, discharge and load.--From auth., p. 206, 210.

3-2160. Moore, Fred E. SUMMARY OF CENOZOIC HISTORY, SOUTHERN LARAMIE RANGE, WYOMING AND COLORADO (In: Weimer, Robert J., and John D. Haun, eds. Guide to the Geology of Colorado: p. 217-222, 2 illus., 5 maps, Denver, 1960) 14 refs.

Tertiary sediments on the E. flank of the Laramie Range suggest that the geomorphic development of the Range has gone through 3 stages. The first stage began with the uplift and dissection of the Range near the end of the Cretaceous and continued until the end of the Eocene. Stage 2 is characterized by the deposition of Oligocene, Miocene, and Pliocene sediments. The third stage, which continues to the present, was initiated by the Pleistocene dissection of the Tertiary mantle. The depositional history of the area indicates that the Sherman surface is a pediment formed by downwasting of the Range contemporaneous with the development of a bajada E. of the Range. Post-Pliocene dissection of the Tertiary mantle has produced the present topography.--Auth.

3-2161. Rocky Mountain Association of Geologists. GEOLOGICAL ROAD LOGS OF COLORADO. Edited by John R. Donnell: 98 p., illus., secs., Denver, 1960) refs.

A complementary volume to the "Guide to the Geology of Colorado," edited by Robert J. Weimer and John D. Haun (see abstracts above). This volume contains logs for regions of surface geologic interest in Colorado which are not contained in the "Guide," and generalized stratigraphic sections of the larger depositional basins in Colorado. The logs were edited to delete extraneous material pertaining to specific conferences; mileages and sequence were adjusted to read equally clearly if the route were traveled in either direction. The only topical paper, "San Luis Valley," by Thad G. McLaughlin, takes the place of an E.-W. road log across the valley.--From foreword.

The 26 roads logs are:

Trinidad to Colorado-Kansas Line.
Trinidad to Colorado-New Mexico Line.
Pagosa Springs to Colorado-New Mexico State Line.
Mineral-Archuleta County Line to Durango.
Bayfield to Durango.
Intersection of U.S. 550 and U.S. 160 Near Durango to Colorado-New Mexico Line.
Durango to Colorado-Utah State Line.
Cortez to Colorado-New Mexico State Line.
Cortez to Whitewater.
Durango to Montrose.
Montrose to Grand Junction.
Newcastle to Meeker.
Rifle to Craig.
Junction U.S. 40 and Colorado 387 to Rio Blanco.
Craig to Utah State Line.
Craig to Maybell.
Steamboat Springs to Craig.
Steamboat Springs to Hayden.
Granby to the Wyoming Line.
Junction Colorado 125 and 127 to Wyoming Line.
From Junction 0.2 Mile East of Rand to Walden.
Kremmling to Dillon.
Glenwood Springs to Intersection of Colorado 82 and U.S. 24.
Rangely to Grand Junction, Colorado.
Poncha Springs to Montrose.
Trinidad to Walsenburg.

3-2162. New England Intercollegiate Geological Association. GUIDEBOOK FOR THE FIFTY-SECOND ANNUAL MEETING. FIELD TRIPS IN WEST-CENTRAL MAINE. Andrew Griscom and Daniel J. Milton, Editors: 38 p., 6 figs., table, Rumford, Maine, Oct. 1960, refs.

W.-central Maine is underlain by metamorphosed and highly deformed Paleozoic sedimentary and volcanic rocks which are intruded by several Devonian plutons ranging in composition from granite to gabbro. Thick Pleistocene deposits cover much of the bedrock. Stratigraphic correlation of rock units is difficult as a result of: complex structure, sedimentary facies changes, metamorphic facies changes, and interruptions of continuity by the Devonian age plutons. The field trips which discuss these bedrock problems will traverse the following quadrangles in W.-central Maine: Stratton (Trip A), Rangeley and Phillips (Trip B), and Old Speck Mountain (Trip D).

Structural interpretations are in some cases tentative where stratigraphic relationships are not completely worked out. Folding of all orders of magnitude is present and isoclinal folding is common. Wolfe (Trip B) considers faulting to be of major importance in the Rangeley and Phillips quadrangles.

In the area of trips A and B the metamorphosed sedimentary rocks range in metamorphic grade from chlorite to staurolite zone. Aureoles of higher grade metamorphism surround the Devonian plutons. In the area of Trip D the grade of regional metamorphism increases to the sillimanite zone. The plutons appear to be at least partly syntectonic in the high grade zones of regional metamorphism and are primarily post-tectonic in the low grade zones of regional metamorphism. The orogeny and metamorphism are primarily of Devonian age.

Trip A (Griscom) traverses the northern portion of the area in the Stratton quadrangle and demonstrates a sequence of rock units which can be correlated in a general way with the lower Paleozoic stratigraphy of the Moosehead Lake area. Trip D (Milton) traverses the Old Speck Mountain quadrangle. Milton informally extends the New Hampshire stratigraphy northeastward from the fossil-dated rocks in the general locality of Littleton and Mt. Moosilauke. This approach involves a correlation over a distance of 50 mi. along which intrusive rocks and structural complication preclude direct tracing of rock units. Trip B (Wolfe) traverses an area in between trips A and D. Here a tentative stratigraphic sequence has been established which as yet cannot be clearly related to either the New Hampshire or the Moosehead Lake sequences.

Pegmatite dikes cut the metamorphic and igneous rocks, being especially abundant in the Rumford area. Trip E (Peacor) visits the pegmatites.

The late Pleistocene and Recent events in W.-central Maine are investigated in the Farmington area on trip C (Caldwell). This trip includes a visit to a pre-Wisconsin Pleistocene till which is believed to be unique in New England.

In both central New Hampshire and the Moosehead Lake area the lower Paleozoic stratigraphic column may be generalized as follows: a diverse assemblage of pre-Silurian sedimentary and volcanic rocks, calcareous sedimentary rocks being scarce; fossiliferous Silurian limey rocks and sandstone with occasional conglomerates, often resting unconformably upon the older rocks; dark gray slates and sandstones of Early Devonian age sometimes with interbedded volcanic rocks but rarely containing limey rocks. The rock units in the Stratton quadrangle (Trip A) fit into the above sequence. Possible correlations of certain rocks in the Rangeley and Phillips quadrangles (Trip B) with the generalized sequence are: arenaceous and calcareous rocks seen near Madrid, Maine, with the Silurian limey rocks; gray siltstones and sandstones seen near Dyer Hill, Maine, with the Early Devonian gray slates. The lack of volcanic rocks in the area of Trip B may indicate that an incomplete section of pre-Silurian rocks is exposed, because there is a considerable thickness of pre-Silurian volcanic rocks to the N. (Trip A) and SW. (Trip D). The Silurian calcareous units are apparently absent in the area of Trip D, but the various metamorphosed sedimentary and volcanic formations can be provisionally assigned an Ordovician to Devonian age. It is presently impossible to correlate clearly with each other all the rock units in the areas traversed by Trips A, B, and D, but a few possibilities have been suggested above.--From introd.

Contents:

3-2163. National Speleological Society. A GUIDE BOOK TO CARLSBAD CAVERNS NATIONAL PARK: Its: Guide Book Ser. no. 1, 43 p., illus., maps, sec., 1960, refs.

CONTENTS:

3-2164. Cook, Earl F. GEOLOGIC ATLAS OF UTAH. WASHINGTON COUNTY: Utah Geol. & Mineralog. Survey, Bull. 70, 115 p., illus. (19 col.,) maps, secs., Sept. 1960, refs.

Washington County, in the SW. corner of Utah, is more or less coincident with the area known as Utah's Dixie, a region of colorful rocks, spectacular scenery, and great contrasts.

Washington County is divided into 2 topographically dissimilar parts by the Hurricane Cliffs. E. of the Hurricane escarpment rise the colorful mesas and plateaus of the Zion Park region. To the W. is a basin and range topography, reflecting more complex geologic structure.

Every period of the Paleozoic and Mesozoic eras with the exception of the Silurian is represented in a sedimentary sequence over 19,000 ft. thick underlain by Precambrian rocks in the Beaver Dam Mountains

and capped by the pink cliffs of the Tertiary Claron (Wasatch) formation in the Pine Valley Mountains. A complex succession of volcanic rocks including flows, breccias, and ignimbrites, aggregating several thousand feet in thickness, overlies the sedimentary sequence. Several laccolithic intrusive bodies in the NW. part of the county are intimately related to volcanism and deformation in that area.

Within Washington County a complete transition in geologic structure takes place from the flat-lying formations cut by a few widely spaced faults of the Colorado Plateau on the E. to the tilted fault blocks of previously folded and thrust-faulted rocks that define the Basin-Range province. As G.K. Gilbert wrote in 1875, "...the whole phenomena belong to one great system of mountain formation, of which the ranges exemplify advanced, and the plateau faults, the initial stages...it is impossible to overestimate the advantages of this field for the study of what may be called the embryology of mountain building."--Auth.

3-2165. Schaeffer, Frederick E., and Warren L. Anderson. GEOLOGY OF THE SILVER ISLAND MOUNTAINS, BOX ELDER AND TOOELE COUNTIES, UTAH, AND ELKO COUNTY, NEVADA: Utah Geol. Soc., Guidebook to the Geology of Utah, no. 15, 175 p. 36 figs., 5 pls. (in pocket) incl. 3 maps, secs., 1960. refs.

The Silver Island Mountains are a NE.-trending range extending from 6 mi. W. of the Utah-Nevada border near Wendover, to about 32 miles NE. of Wendover, Utah. The range is in the NE. part of the Basin and Range province and is a part of the Great Salt Lake Desert. The mountains consist of 3 main segments, 2 of which are termed "islands." The northern and central segments are known as Crater Island and Silver Island respectively, and the southern segment is known as the Leppy Range. The range has a maximum relief of about 3,000 ft., the highest point being 7,300 ft., on Silver Island. The highest elevation on Crater Island is 5,675 ft. The highest elevation in the Leppy Range is 6,698 ft. The Lacustrine plain surrounding the range has an average elevation of about 4,220 ft.--From introd.

Chapters cover: historical background of the area; stratigraphy of the Silver Island Mountains; stratigraphic section of the northern Silver Island Mountains; igneous rocks of the northern Silver Island Mountains; igneous rocks of the central and southern Silver Island Mountains; structural geology of the northern Silver Island Mountains; structural geology of the central and southern Silver Island Mountains; geomorphology of the Silver Island Mountains; and economic geology of the northern Silver Island Mountains. A road log concludes the guidebook.

3-2166. Nalivkin, D.V. THE GEOLOGY OF THE U.S.S.R., A SHORT OUTLINE. Translated from the Russian by S.I. Tomkeieff: 170 p., 2 maps incl. col. geol. map (2 sheets, under separate cover), scale 1:7,500,000, table, London-New York, Pergamon Press, 1960.

The geological map of the U.S.S.R. will show the inhomogeneity of the structure of the territory of the Union. Most apparent are the 2 great platforms. To the W. is situated the Russian platform, a region of almost horizontal Paleozoic, Mesozoic, and Tertiary rocks. To the E. there is another region of horizontal Paleozoic and Mesozoic rocks - the Siberian platform.

The Russian and Siberian platforms represent 2 Precambrian geosynclines, in the region of which folding occurred up to the close of the Proterozoic era. In places, along their borders, these platforms were affected by lower Paleozoic foldings which enlarged their borders, as for example along the E. border of the Russian platform.

Between the Urals and the Siberian platform the W. Siberian lowlands are situated, a vast depression filled with Mesozoic and Tertiary deposits reaching in places a thickness of 4,000 m., as shown by the isolines of the Paleozoic floor. Geophysical observations and the results of deep borings show that the northeastern half of the lowlands is underlain by a continuation of the Siberian platform and must therefore be assigned to a Precambrian geosynclinal region. On the other hand the southwestern half of the lowlands is formed by folded Paleozoic rocks and therefore must be assigned to a Paleozoic geosyncline.

The Paleozoic geosynclines are characterized by the predominance of folded Paleozoic rocks and Paleozoic granites. In places intensely metamorphosed Precambrian rocks are also to be found in them. The Mesozoic and Tertiary rocks are mostly unfolded, only the Upper Triassic and the Lower and Middle Jurassic rocks occurring in wide flat folds.

The main regions belonging to the Paleozoic geosynclines are as follows: Urals, Tian-Shan, western Arctic, eastern Kazakhstan, Altai and western Transbaikal region. The Mesozoic-Tertiary groups of geosynclines include 2 very wide geosynclinal regions - the Mediterranean and the region of the Pacific Ocean. The first includes the Carpathians, the Crimea, the Caucasus, Kopet-Dagh, and the southern ridges of Central Asia, including the Pamir. The second covers the eastern Transbaikal and Amur regions, Sikhote-Alin, Sakhalin, Kamchatka, and northwestern Siberia.

On the map the 2 regions are well marked because of the dominance of folded Mesozoic and Tertiary deposits. They are characterized also by a wide development of volcanic effusions and igneous intrusions of the same age.

A zone of problematic structural position includes the Dnepr-Donetz depression with the Donetz basin, the Manych depression, Mangyshlak, and Tuar-Kyr. This zone is closely connected in equal measure with the Russian platform, the Uralian geosyncline, and the Mediterranean geosynclinal region. The development of the regional folded Triassic, Jurassic, and Lower Cretaceous rocks, weakly folded Upper Cretaceous and Paleogene rocks, and unfolded Neogene rocks suggests that this zone belongs to the outer part of the Mediterranean geosyncline.--From Auth. introd.

For each region of the U.S.S.R. the author provides a brief outline of relief, stratigraphy, tectonics, magmatism, and economic deposits. This book is divided into 10 areas: Russian platform, Siberian platform, West Siberian lowlands, Ural mountains, Western Arctic and Timan, Angara geosyncline, Central Asia, Mediterranean geosyncline, Northwestern border of the Mediterranean geosyncline, and Pacific Ocean geosyncline.

See also: Geologic Maps 3-2112, 3-2116, 3-2117, 3-2118; Areal and Regional Geology 3-2143, 3-2159, 3-3-2160, 3-2163; Stratigraphy 3-2248, 3-2249; Mineralogy 3-2340; Geohydrology 3-2399.

3-2167. Gerasimov, I. P. THE MAIN TASKS AND TRENDS OF GEOMORPHOLOGICAL RESEARCH IN THE USSR: Soviet Geography, v. 2, no. 3, p. 35-43, March 1961.

The main defect of current texts in geomorphology is the absence of a single broad ideological concept underlying the formation of the scientific viewpoint of the young geomorphologist. Rather than argue whether geomorphology is a branch of geology or geography, it should be considered an independent science between the two.

According to Soviet geomorphology, the relief of the earth's surface is formed by the continuous, historically developing interaction of external (exogenic, physical-geographic) and internal (endogenic, geologic) factors. All the relief elements of the earth's surface, from the smallest to the largest, are closely interrelated and must always be studied with a view to such an interrelationship. Field study involving direct observation is a cardinal feature of geomorphic analysis.--M. Russell.

3-2168. Flint, Richard Foster, and Friedrich Brandtner. CLIMATIC CHANGES SINCE THE LAST INTERGLACIAL: Am. Jour. Sci., v. 259, no. 5, p. 321-328, fig., May 1961, 22 refs.

Six curves, from European and American localities, showing inferred fluctuations of climate (chiefly temperature) during various segments of the time since the last interglacial, are compared. The curves are time calibrated by C^{14} dates. Agreement among the curves is very good. Comparison with curves based on isotopic temperatures, derived from pelagic Foraminifera in deep-sea sediment cores, also shows good agreement. It is concluded that a broad pattern of fluctuation of climate, within the time range considered, is becoming evident.--Auth.

3-2169. Heusser, Calvin J. LATE-PLEISTOCENE ENVIRONMENTS OF NORTH PACIFIC NORTH AMERICA; AN ELABORATION OF LATE-GLACIAL AND POSTGLACIAL CLIMATIC, PHYSIOGRAPHIC, AND BIOTIC CHANGES: Am. Geog. Soc., Spec. Pub. no. 35, 308 p., 49 figs. incl. maps, graphs, 25 pls., 10 tables, 1960, approx. 400 refs.

N. Pacific coastal America from Washington to southwestern Alaska was mantled almost completely by a glacier complex ca. 11,000 B. P. Late-glacial ice had begun to recede from the Puget Lowland terminal moraine in western Washington at least as early as 14,000 B. P., but an important readvance occurred ca. 11,300 B. P. Large-scale postglacial recession was in progress by ca. 10,500 B. P. at latitude 49°N. in southern British Columbia, by ca. 10,000 B. P. near latitude 54°N. in northern British Columbia and southeastern Alaska, and by 9,000 B. P. near latitude 60°N. in S.-central Alaska. These conclusions are based largely on the radiocarbon dating of the basal fractions of peat deposits situated on this coast.

Since late-Pleistocene glacier recession began, N. Pacific America has undergone a series of climatic, physiographic, and biotic changes. The natural vicissitudes that have taken place since ice retreat have been determined by a study of the pollen and peat stratigraphy of 114 sections collected from muskegs, bogs, and lakes situated between Kodiak Island, Alaska, and northern California. Radiocarbon dating, for the most part, is the basis for the chronologies of the environmental changes.

A late-glacial sequence, considered equivalent to Older Dryas, Alleröd, and Younger Dryas of the European chronology, is recognized only on the Olympic Peninsula of western Washington. Sections northwestward of the Olympic Peninsula contain only the closing late-glacial interval (Younger Dryas). No late-glacial data are available from southwestern Alaska.

Postglacial time on the N. Pacific coast, ensuing between ca. 10,500 B. P. and 9,000 B. P., is subdivided into 3 major intervals which resemble those categorized by von Post. This sequence shows a cold, moist climate during the opening interval, drying and warming later reaching a temperature maximum (Hypsithermal), and a return to a climate marked by cooling and rising humidity, which has fluctuated to the present.

Lodgepole pine and alder are prominent components of early-postglacial vegetation between Washington and southeastern Alaska. Northwesterly, in S.-central and southwestern Alaska, fern and sedge are notable. Alder is less conspicuous and umbellifers more so westward along the Gulf of Alaska. No record was obtained from Oregon and California where the sections begin during the hypsithermal. During early-postglacial time, coastal tundra is increasingly manifest at higher latitudes.

A gradual rise of conifer forest over the length of the hypsithermal occurs southeasterly from Prince William Sound. SW. of the sound, alder and birch are most noteworthy and on the Kenai Peninsula are found with grass (Gramineae) and sedge. Mountain hemlock, accompanied by alder, appears in Prince William Sound. It is a minor constituent of the forest in the Alexander Archipelago, and in coastal British Columbia and Washington early in the interval, the species gains only a transitory prominence, often with fir. Sitka spruce (Picea sitchensis) and western hemlock (Tsuga heterophylla), in the company of alder, are the principal conifers from Icy Cape, Alaska, to northern British Columbia. This assemblage develops also in Oregon. In southern British Columbia and Washington, however, these trees become mixed with Douglas fir (Pseudotsuga menziesii), western white pine (Pinus monticola), and alder. In parts of Washington, oak (Quercus) reaches maximum numbers. California vegetation is a mosaic of grass, composites (Compositae), alder, and Bishop pine (Pinus muricata).

A Grenzhorzont, particularly striking in southeastern Alaska and British Columbia muskeg, marks the boundary between the hypsithermal and late postglacial in many of the sections. In southeastern Alaska it is radiocarbon dated at ca. 3,500 B. P. Ligneous peat, preserved from the hypsithermal when forest had invaded muskeg, underlies sphagnum that regenerated during the late postglacial at the expense of the forest. Heath also forms a part of the regeneration complex at this time. In addition, lodgepole pine, released from competition with upland-forest trees, becomes established on the muskeg.

Western hemlock, with Sitka spruce and often with mountain hemlock, becomes luxuriant from southeastern Alaska to Oregon during the late postglacial. In Prince William Sound, mountain hemlock is the principal tree, and western hemlock rises in proportion during this interval. Sitka spruce is a late-postglacial migrant along the ocean coast of the Kenai Peninsula and on Afognak and Kodiak Islands. On the Cook Inlet side of the Kenai, white and black spruces (Picea glauca and P. mariana) appear, having migrated from the interior of Alaska. In California,

alder and Bolander pine (Pinus bolanderi) gain in number, although grass and composites remain noteworthy components of the vegetation.

During the Alaskan postglacial at least 5 major volcanic eruptions are recorded, as indicated by ash horizons embedded in the peat sections. The oldest is of Mt. Edgecumbe in the southeastern "panhandle," and the youngest is of Mt. Katmai in the Aleutian Range. The 3 remaining eruptions are in the Aleutian Range and Wrangell Mountains. The major postglacial eruptions southward are those of Glacier Peak in Washington and Mt. Mazama in Oregon.

A brackish-water phase in the postglacial history of coastal lakes in Alaska, Washington, and Oregon is dated between ca. 6,500 and 4,000 B. P. This transgression is thought to represent a eustatic sea-level change that occurred during the hypsithermal. Postglacial changes in land and sea-level relations resulting from differential uplift are measured and dated about Katalla, Lituya Bay, and Juneau, Alaska.

Pollen-stratigraphical and chronological correlations of environmental changes are attempted with other areas in the United States and with Hawaii, Japan, New Zealand, Fuego-Patagonia, Tristan da Cunha, and the British Isles. A general parallelism is in evidence but synchronism is apparent only in certain instances.

Phytogeographical aspects take into account the existence and location of ice-age "nunataks" or refugia and the patterns of migration. Refugia appear to have been located 1) S. of the ice limit; 2) on the higher parts of Vancouver Island, 3) in the Queen Charlotte Islands, 4) in the Alexander Archipelago, 5) at places between Icy Point and the mouth of the Copper River, 6) around Prince William Sound, and 7) on the Kenai Peninsula. Plants have migrated from some if not all of these and from refugia in the continental interior. Pollen data from the Kenai Peninsula are significant in that they supply evidence that the locus indicated by Hultén for his western American coast radiants did in fact exist.

Passing consideration is given to the antiquity of man and the routes he followed in his generally accepted immigration from Asia. Although most anthropologists believe that early man traveled southward along the Rocky Mountain front, favor is attached to pre-Wisconsin coastal migration via the Aleutian Islands and archipelagoes of Alaska and British Columbia. Because the dates referable to postglacial man N. of the southern limit of the ice sheet do not extend back earlier than ca. 5,000 B. P., it would seem that his migration has been northward from unglaciated southern North America, where his antiquity is greater than 5 millennia and a cultural relationship is probable.--From auth.

3-2170. Emiliani, C., and others. PALEOTEMPERATURE ANALYSIS OF THE PLIO-PLEISTOCENE SECTION AT LE CASTELLA, CALABRIA, SOUTHERN ITALY: Geol. Soc. America, Bull., v. 72, no. 5, p. 679-688, 2 figs., 2 tables, May 1961, 24 refs.

The Plio-Pleistocene boundary has been located at the place where certain northern species of marine invertebrates first appear in the continuous Plio-Pleistocene sections of Italy. The section at Le Castella, near Crotone, southern Italy, consists of clays with diatomaceous layers and a few thin sand layers. The Plio-Pleistocene boundary there is clearly marked by the appearance of Anomalina baltica and other northern species of Foraminifera. Calabrian (lower Pleistocene) sediments 210 m. thick overlie the boundary, and upper Pliocene sediments 1,405 m. thick underlie it. The fossil fauna of the Plio-Pleistocene section consists essentially of abundant pelagic and benthonic Foraminifera, and diatoms. The benthonic microfauna indicates a depositional depth of about 500 m. There is no evidence of turbidity currents and submarine slumping.

A section 167.80 m. thick, including the paleontologically defined Plio-Pleistocene boundary, was logged and sampled at close stratigraphic intervals. O isotopic analyses of different species of pelagic and benthonic Foraminifera and of shell fragments of benthonic mollusks at successively higher stratigraphic positions in the section have revealed numerous temperature oscillations. Surface temperatures, probably representing summer averages, as indicated by Globigerinoides rubra and G. sacculifera, ranged from 21°C. to more than 30°C. in the late Pliocene, from 16°C. to more than 30°C. in the late Pliocene-early Pleistocene, and from 12°C. to 28°C. in the late Pleistocene. Temperatures at some depth and/or at a season other than the summer, as indicated by Globigerina bulloides and G. inflata, ranged from 20°C. to 28°C. in the late Pliocene, from 11°C. to 22°C. in the late Pliocene-early Pleistocene, and from 9°C. to 18°C. in the late Pleistocene. Temperatures given by benthonic Foraminifera ranged from 14°C. to 20°C. in the late Pliocene and from 11°C. to 22°C. in the late Pliocene-early Pleistocene (no data available for the late Pleistocene). Temperatures above 30°C. may be due, in part, to isotopic effects of the sea water. The above figures clearly indicate a major shift of the temperature ranges toward lower values from the late Pliocene to the late Pleistocene.

No major temperature change seems to have occurred across the paleontologically defined Plio-Pleistocene boundary. Since the secular temperature minima of the late Pliocene are somewhat lower than present average summer temperature, an areal extension of the ice somewhat greater than that at present is suggested. Such extension probably increased at the times corresponding to the even lower temperature minima of the early Pleistocene. Major continental glaciations, however, may not have started until later, because none of the temperature minima in the section at Le Castella appear to have reached values as low as those obtaining during the glacial ages in the eastern Mediterranean.

The temperature changes in the section at Le Castella are paralleled by important changes in the microfauna.--Auth.

3-2171. Bowen, Robert. PALEOTEMPERATURE ANALYSES OF MESOZOIC BELEMNOIDEA FROM AUSTRALIA AND NEW GUINEA: Geol. Soc. America, Bull., v. 72, no. 5, p. 769-773, 2 figs., table, May 1961, 9 refs.

Paleotemperature analyses were carried out on more than 60 Belemnoidea obtained from Mesozoic strata in West and South Australia and New Guinea. One set of data records mean rostral temperatures, and another derived by analyzing successive increments of powdered carbonate from the rostra shows the variations of temperature during ontogenies. The latter probably represent and in this event would confirm seasonal changes during the Mesozoic. The former demonstrate a cooling from the Jurassic into the Cretaceous and are consistent with the extension of the Albian and Coniacian-Santonian climatic maxima, previously demonstrated in Europe, into the Australian area. The Cretaceous readings dispose of the idea of an ice age in South Australia at that time. It appears that the Belemnoidea were eurythermal through most of their evolutionary

history. The paleotemperature results are in accord with a possibly large migration of Australia during the Mesozoic.--Auth.

3-2172. Merrill, William M. STRUCTURES IN GLACIER ICE, NORTH ICE CAP, NORTHWEST GREENLAND (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 21. Other Subjects, p. 68-80, 7 figs., table, 1960) 2 refs.

Structures in glacier ice, including tension cracks, "blue bands," foliation, planar and linear bubble trends, dirt zones, shear features, and orientation of optic axes of ice crystals, were mapped and studied by conventional methods in a small drainage basin along the cliffed margin of the SE. edge of North Ice cap, northern Nunatarssuaq, NW. Greenland. Data were obtained from the surface of the glacier, the cliff face, the toe at the base of the cliff, and from ice exposed in 2 tunnels which were dug a distance about 30 m. into the ice cliff. Observations were extended over 2 field seasons, from mid-June through August in 1955, and from mid-June through July in 1956.

Orientation and distribution of bubbles, foliation, and other planar features are temporary, changing rapidly in response to changes in directions and rates of ice motion. Direction of motion generally parallels foliation, but motion is erratic in direction and rate so that "turbulence" is generated within the ice mass. Orientation of optic axes is strongest in the most actively moving ice, varies with changes in direction and rate of ice motion, and probably tends to alter somewhat sooner than changes in folia orientation. --Auth.

3-2173. Smith, David D. ORIGIN OF PARALLEL PATTERN OF MELTWATER LAKES ON FLETCHER'S ICE ISLAND, T-3 (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 21. Other Subjects, p. 51-59, 4 figs., 1960) 10 refs.

Ice Island T-3 is composed primarily of iced firn which contains numerous elongate, lensoid bodies of old lake ice that formed during buildup of the parent, now degrading Ellesmere ice shelf. Ablation is currently exhuming these bodies. Areas of T-3 underlain predominantly by old lake ice become broad ridges because this ice is more resistant to ablation. By contrast, areas underlain by iced firn become valleys occupied by modern meltwater lakes.

Thus structural control produced by parallel bodies of old lake ice causes the parallel modern lake pattern so typical of T-3 and, presumably, causes the similar pattern on the Ellesmere ice shelf. Accordingly, explanation of the modern lake pattern requires explanation of the lake pattern during shelf buildup.

Hattersley-Smith proposed that modern inter-lake ridges result from the perpetuation, by channelized meltwater runoff, of parallel seif-like snow dunes present on the shelf surface when the current degradational phase began. Several lines of evidence strongly support existence of such dunes during shelf buildup but indicate they actually served as control for meltwater lakes which formed the old lake ice bodies expressed today as inter-lake ridges. Thus the parallel pattern of the structural control results from the original dune-controlled orientation of lakes during shelf buildup.--Auth.

3-2174. West, Robert, and Arthur Maki. AN ADVANCING GLACIER IN CANADA: Science, v. 133, no. 3461, p. 1361, illus., Apr. 28, 1961, 7 refs.

The Commander Glacier, in the Purcell Range of interior British Columbia, advanced 810 ± 50 ft. in the 6 years 1954-1960. The advance may be a response to a general cooling trend previously noted elsewhere in the Pacific Northwest.--Auth.

3-2175. Crary, A. P. GLACIOLOGICAL REGIME AT LITTLE AMERICA STATION, ANTARCTICA: Jour. Geophys. Research, v. 66, no. 3, p. 871-878, 6 figs., 2 tables, March 1961, 16 refs.

Factors affecting changes in the floating Ross ice shelf in the vicinity of the 1957-1958 IGY Little America Station are examined. From direct measurements, the amount of snow accumulation was 67 cm. annually, or 26 cm. ice equivalent. The principal horizontal strain rates, determined from repeated transit surveys, were 129 and 81 x 10^{-5} per year, with the minimum values in the approximate direction of motion. The maximum strain rate may be deduced from Weertman's formula for the creep of floating ice, using acceptable flow law constants. Vertical strain accompanying the horizontal strains should reduce the ice thickness by 54 cm./yr. From the known variations in ice shelf temperature with depth, 80 cm. of melting at the ice-water interface is deduced. The net change for these factors would be an annual thinning of the ice shelf of 108 cm., equivalent to a decrease in surface elevations of 18 cm./yr. For the average surface slope in the Little America area of 65 cm./km., a forward ice shelf motion of 277 m./yr. would be required, if elevations at fixed points remain constant with time. This velocity is comparable to that which has been deduced from the movement of Kainan Bay since it was first observed in 1912 by the Japanese Antarctic Expedition. Extrapolation of the creep rates and amounts of bottom melting S. from the barrier edge give ice thinning that would result in somewhat higher ice movement values. Although the validity of the extrapolation to thicker ice is questionable, it appears likely that the ice W. of Roosevelt Island is moving northward 3 to 4 times faster than the ice E. of the island.--Auth.

3-2176. Dreimanis, Aleksis. PRE-CLASSICAL WISCONSIN IN THE EASTERN PORTION OF THE GREAT LAKES REGION, NORTH AMERICA (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 4. Chronology and Climatology of the Quaternary, p. 108-119, 3 figs., 1960) 46 refs.

Differences in the content of garnets and carbonates in matrix of tills in Ontario, Ohio, Pennsylvania, and New York suggest that the principal centers of glacial outflow were farther E. during the early Wisconsin (or pre-classical Wisconsin, post-Sangamon) than during the maximum of the main or classical Wisconsin. This may explain why the early Wisconsin drift has not been found W. of the above areas in the Great Lakes region. The early Wisconsin glacial cover could have been more extensive along the Atlantic border of North America, if this area was topographically higher than at present, as suggested by inferences of lake levels in the Ontario basin.

The early Wisconsin ice sheet advanced, with oscillations approximately 66,000 radiocarbon years B. P., over S. Quebec southwestward. Its retreat was followed by a long cool mid-Wisconsin interstadial. In Ontario a mid-Wisconsin glacial advance, 44,000 years B. P., reached as far as Lake Erie and split the long interstadial in 2: the earlier, Port Talbot,

and the later, Plum Point, ending approximately 26,000 years B. P. Lithologic composition of the mid-Wisconsin drift is more similar to the main or classical Wisconsin than the early Wisconsin till N. of Lake Erie, suggesting shifting of centers of glacial outflow westward already during the mid-Wisconsin.--Auth.

3-2177. Putnam, William C. FAULTING AND PLEISTOCENE GLACIATION IN THE EAST-CENTRAL SIERRA NEVADA OF CALIFORNIA, U. S. A. (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 21. Other Subjects, p. 270-274, fig., 1960) 4 refs.

At McGee Mountain, on the eastern slope of this lofty mountain range, the deposits of the oldest glacial stage occur at an altitude of 10,000-10,800 ft. on a broad, upland surface. These tills were named the McGee stage by Blackwelder, but have not been studied in detail since.

McGee stage moraines are cut by normal faults whose probable displacement is 3,000-4,000 ft., and thus the deposits provide a measure of the minimum later Pleistocene uplift of the mountain. Late Pleistocene moraines, occupying deeply-incised canyons are cut by faults whose smaller offsets decrease with recency of age.

At no other place in eastern California are earlier and later glacial deposits so completely represented in such close proximity. The purpose of this paper is to give a detailed description of the deposits of the McGee glacial stage, to discuss their relationship to the recent uplift of the Sierra Nevada, and to relate these earlier moraines to the later ones which now occupy the floors of canyons which were excavated approximately 2,000 ft. in the time intervening between the deposition of the 2.--Auth.

3-2178. Willden, Ronald, and Don R. Mabey. GIANT DESICCATION FISSURES ON THE BLACK ROCK AND SMOKE CREEK DESERTS, NEVADA: Science, v. 133, no. 3461, p. 1359-1360, 3 illus., Apr. 28, 1961, 5 refs.

Open fissures, from 100 to several hundred feet apart, that have produced polygonal patterns on the Black Rock Desert, Nevada, are believed to be giant desiccation cracks resulting from a secular trend toward aridity in the last few decades. Similar features on the Smoke Creek Desert probably have the same origin.--Auth.

3-2179. Gray, Don M. INTERRELATIONSHIPS OF WATERSHED CHARACTERISTICS: Jour. Geophys. Research, v. 66, no. 4, p. 1215-1223, 6 figs., 2 tables., Apr. 1961, 15 refs.

The application of the principles of dimensional analysis to obtain the relationships between characteristics of the unit hydrograph and topographic and morphometric properties of a watershed is not possible unless careful consideration is given to the selection of variables. Evidence is presented which shows that, in small watersheds, drainage-area size A, length of the main stream L, and length to center of area L_{ca} are highly correlated. In addition, the results indicate that, when consideration is given to regional influence, the slope of the main stream S_c can be expressed as a function of A, L, or L_{ca}.--Auth.

3-2180. Laidly, W. T. SUBMARINE VALLEYS IN LAKE SUPERIOR: Geog. Rev., v. 51, no. 2, p. 277-283, 7 figs., Apr. 1961, refs.

The U.S. Lake Survey, making navigation charts for the Great Lakes, sounded Lake Superior in 1957-1958 and discovered a network of ridges and valleys in the eastern end. In places, valley bottoms are more than 700 ft. below the tops of intervening ridges; the valleys range in width from half a mile to several miles. Greatest depth recorded is 1,333 ft. (valley bottom at that point is about 731 ft. below sea level). The survey ship, its equipment, and sounding methods are described in detail. Soundings are made by 2 depth finders, one with a 210-ft. range, the other with 400-ft., 400-fathom, and 4,000-fathom ranges. In 1957, an electronic position indicator was used for positioning; in 1958 shoran was also used.

The valleys discovered extend in a general N.-S. parallel system, in a region of strong faults in Cambrian sandstone, overlain by younger sediments, mainly limestone, to the S. Pleistocene glaciers have perhaps been the greatest modifiers since the faulting. Michipicoten Island formed a dam that diverted ice to E. and W., and in its shadow glaciers excavated deep, continuous valleys in pre-existing fracture zones. A shoal sample NW. of Caribou Island consisted mainly of angular sandstone fragments; Cambrian sandstone may extend northward almost to Michipicoten. On the Canadian shore, where glacial drift is thin, several large river valleys can be traced into the lake submarine valleys. The floors of both valley groups are sand filled.

The geological history of all of Lake Superior is briefly outlined.--R. L. Heinecke.

3-2181. Lugn, Alvin Leonard. THE ORIGIN AND SOURCES OF LOESS IN THE GREAT PLAINS IN NORTH AMERICA (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 21. Other Subjects, p. 223-235, 3 figs., table, 1960) 25 refs.

The writer has proposed in several earlier publications a "regional source area" or "desert source" for the provenance of most of the loess deposits in Nebraska, Kansas, and some other adjacent areas. River flood plains are admittedly important sources of loess dust; and in certain regions, most of the loessic deposits have been blown up from river floodplains. This appears to be the only plausible source for the relatively thin loess in Illinois, the thicker loess deposits of the lower Mississippi Valley, and of the loess of western Germany.

River flood plains of Nebraska and Kansas have made significant contributions to loess sedimentation, especially in the formation of narrow "loess lips" adjacent to valleys in certain places and on the leeward sides, but this source has been wholly inadequate to have supplied the quantity and to have been responsible for the distribution of the loess as it occurs in the central Great Plains.

The Great Sand Hills region in Nebraska and other sand dune areas, which are underlain by Ogallala (Pliocene) fluvial deposits, are postulated as the most probable "desert" sources for most of the "Peorian" loess deposits. Fluvial sediments, such as the Ogallala beds, are generally agreed to be the best and most likely source materials for loess.--Auth.

3-2182. Scheidegger, Adrian E. EVALUATION OF SLOPE DEVELOPMENT THEORIES: Alberta Soc. Petroleum Geologists, Jour., v. 9, no. 1, p. 15-19, 26, 4 figs., Jan. 1961, 7 refs.

The various theories of slope development advanced by field geomorphologists are analyzed in terms of physico-mathematical models. It is shown that the principle of unequal activity advocated by Crickmay is best compatible with possible physical processes.--Auth.

3-2183. McMillan, Neil J. SOILS OF THE QUEEN ELIZABETH ISLANDS (CANADIAN ARCTIC): Jour. Soil Sci., v. 11, no. 1, p. 131-139, illus., March 1960.

A geological reconnaissance of the northernmost group of islands of the Canadian Arctic (Queen Elizabeth Islands) afforded an opportunity to study the nature of the soils. Profile development is rare, and the nature of the soil surface mainly depends on the slope of the ground and the type of bedrock. Chemical weathering and plant action are almost negligible in the arctic environment. Three profiles were examined in detail, 2 in well-drained positions and one probably waterlogged for most of the thaw period. It is concluded that soils of this area should properly be regarded as polar equivalents of lithosols and regosols and that they should not be classed with the Tundra great soil group. The name Rawmark great soil group is suggested to encompass such soils of polar environment both in the northern and southern hemispheres.--Auth.

3-2184. Wallis, James R., and Lee J. Stevan. ERODIBILITY OF SOME CALIFORNIA WILDLAND SOILS RELATED TO THEIR METALLIC CATION EXCHANGE CAPACITY: Jour. Geophys. Research, v. 66, no. 4, p. 1225-1230, 2 figs., 3 tables, Apr. 1961, 8 refs.

The inherent erodibility of 20 soils was indexed using Middleton's dispersion ratio and Anderson's surface-aggregation ratio. These indices were then used as dependent variables for several regression analyses. The milliequivalents per 100 grams of oven-dried soil for the 4 most plentiful soil cations (Ca, Mg, K, and Na) were determined and then used as independent variables in the regressions.

The best fit to the data was found to be an equation of the type:

$$\text{Erosion index} = a + b\left(\text{meq of } Ca^{++} + Mg^{++}\right) + c\left(\text{meq of } Ca^{++} + Mg^{++}\right)^2$$

Both the linear and the curvilinear terms were significant at the arbitrarily selected 5% level.--Auth.

3-2185. Perelman, A.I. GEOCHEMICAL PRINCIPLES OF LANDSCAPE CLASSIFICATION: Soviet Geography, v. 2, no. 3, p. 63-73, table, March 1961.

The lack of a generally accepted scheme of landscape classification prompted the author to construct a classification based on geochemical methods. In setting forth the principles involved, the following are considered: systematic and nonsystematic features; widespread and rare landscapes; the major systematic landscape features, principal and secondary elements; abiogenous and biogenous landscapes; the biological circulation of atoms; main groups, types and subtypes of biological circulation; geographical distribution of landscape groups and types; water migrants and delimitation of landscape classes. The total number of geochemical landscape classes is not very large; the 4 most common landscapes (tundra, taiga, steppe, and humid tropic) fall into 6 or 7 basic geochemical classes based on typomorphic elements of water migration.--M. Russell.

3-2186. Richards, Horace G. CORRELATION OF PLEISTOCENE SHORE LINES OF NORTH AMERICA WITH THOSE OF EUROPE (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 4. Chronology and Climatology of the Quaternary, p. 58-61, 1960) 20 refs.

Along the E. coast of North America S. of the terminal moraine (near New York City) there is paleontological evidence of one Pleistocene high sea level. This is referred to the Sangamon interglacial. There is physiographic evidence of an older shoreline at elevation about 90 ft. This is tentatively also referred to the Sangamon. There is less definite evidence of older (higher) Pleistocene shorelines.

An attempt is made to correlate the North American marine Pleistocene shorelines with those of the Mediterranean area. One possible difficulty lies in the different diastrophic history of the 2 regions. There is good evidence that the Mediterranean area has been elevated, while that of eastern North America may have remained stable or subsided. Other possible factors are discussed.

The marine Pleistocene deposits N. of the terminal moraine – that is in New England and eastern Canada – are thought to be largely post-Wisconsin age and can in many cases be correlated with similar deposits in Scandinavia.--Auth.

3-2187. Zeigler, John M. BEACH STUDIES IN THE CAPE COD AREA CONDUCTED DURING THE PERIOD AUGUST 1953-APRIL 1960: Woods Hole Oceanog. Inst., [Tech. Rept.], Ref. No. 60-20, 32 p., 11 figs., 21 pls., 3 tables, Apr. 1960, 23 refs.

Six years of field data and the conclusions of 8 published papers and 2 papers "in press," are included in this final report. Wherever possible the writer has attempted to sum up significant unpublished data by the use of illustrations. All other research, whether fruitful or not, is summed up as concisely as possible.

The report may best be considered in 3 parts: 1) introduction, description of the area, and a discussion of technique; 2) beach and coastal regimen which includes profile studies, aerial photography, and coastal erosion studies; and 3) sediment distribution and wave dynamics.--From auth.

3-2188. Richards, Adrian F. RATES OF MARINE EROSION OF TEPHRA AND LAVA AT ISLA SAN BENEDICTO, MEXICO (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 10, Submarine Geology, p. 59-64, 4 figs., 1960) 9 refs.

The southeastern shoreline on the leeward side of Isla San Benedicto, Mexico, was extended about 900 m. seaward by tephra and lava during the life of Volcán Bárcena, which was born on Aug. 1, 1952, and became inactive in early 1953. Effects of marine erosion were followed from 1952 until 1957 by photographic flights and visits by ship to the island. An estimated $7 \times 10^5 m.^3$ (about 17,000 $m.^3$/day) of tephra was eroded by wave action from Volcán Bárcena between Aug. 11 and Sept. 20, 1952. The bulge of Bárcena cone which extended farthest out to sea was eroded at a rate of slightly less than 1 m. /day during this period. Lava flowed about 650 m. out to sea from Bárcena between Dec. 1952 and March 1953.

The seaward 18 m. of flow tongues exposed to wave attach were eroded away during the summer storm season between observations made on Apr. 16 and Sept. 21, 1953. This represents an average rate of about 11 cm./day, but erosion probably proceeded at varying rates depending on storms. Vertical cliffing of the flow tongues occurred during this period and subsequent erosion was relatively slight.--Auth.

3-2189. Alexander, Charles S. THE MARINE TERRACES OF ARUBA, BONAIRE, AND CURAÇAO, NETHERLANDS ANTILLES: Assoc. Am. Geographers, Annals, v. 51, no. 1, p. 102-123, 14 figs. incl. illus., maps, March 1961, refs.

Aruba, Bonaire, and Curaçao, the leeward islands of the Netherlands Antilles are rimmed by several clearly defined marine terraces which, throughout much of the length of the islands' coasts, are cut into coral limestone. They are explained as having been formed on a constantly rising land during periods of changing interglacial sea levels. Age correlation of the terraces is summarized.--M. Russell.

3-2190. Fisher, Robert L. MIDDLE AMERICA TRENCH: TOPOGRAPHY AND STRUCTURE: Geol. Soc. America, Bull., v. 72, no. 5, p. 703-719, 5 figs., 6 pls., 2 tables, May 1961, 35 refs.

From 1952 to 1959, during 9 expeditions of the Scripps Institution of Oceanography and one of the U.S. Navy Electronics Laboratory, research vessels recorded 31,950 mi. of echo-sounding traverses in and adjacent to the Middle America trench, which extends from the Islas Tres Marías off western Mexico to the Cocos Ridge SW. of Costa Rica.

The Middle America trench is continuous at depths greater than 2,400 fathoms (4,400 m.) for 1,260 mi., except off Manzanillo and Zihuatanejo, Mexico, where submarine mountains lie in the trench. It is deeper than 3,000 fathoms (5,500 m.) for 380 mi. as the Guatemala Deep. NW. of Acapulco it is generally U-shaped in cross section, with a steeper shoreward flank and a flat bottom suggesting sedimentary fill. From Acapulco SE. to the W. side of the Gulf of Tehuantepec, the trench shoals, in a series of basins, to 2,700 fathoms (5,000 m.). To the SE. it widens and deepens abruptly to a maximum 3,500 fathoms (6,400 m.) off western Guatemala, then shoals gradually to merge into the sea floor off Costa Rica. The SE. segment is also asymmetrical in cross section but is V-shaped with irregular bottom. A NE.-trending band of ridge-and-trough topography, 60 mi. wide, separates the 1,800- to 1,900-fathom sea floor outside the trench off southern Mexico from the 2,100- to 2,200-fathom Guatemala basin. This zone has been traced from several hundred miles offshore to an intersection with the trench near the W. side of the Gulf of Tehuantepec.

Seismic-refraction studies reported in an accompanying paper [see below] were employed in determining the trench structure. Three refraction stations were taken along the axis of the trench W. of Acapulco and 2 along its axis off Guatemala and El Salvador. Another station was shot on the shelf and one 60 mi. seaward of the trench off Guatemala. Thick sediments were found in the Tres Marías basin off Manzanillo and at the shelf station off Guatemala. Arrivals from rock with compressional wave velocity of 4-6 km./sec. were observed at the Tres Marías basin and Guatemala shelf stations. Off Guatemala, on a section normal to the trench, the depth below sea level to the M discontinuity is interpreted from these seismic data as about 9 km. (Pacific basin), 10 km. (outer ridge), 16 km. (trench), and 17 km. (shelf). Below the sea floor the crust thickens from 5-7 to 10-17 km. along this section. The M discontinuity is deeper and the crust below the sediments thicker under the 2 southern stations than under the 2 central trench stations. The mantle is deeper under the Tres Marías basin, where thick (1 1/2 km.) sediments are found, than under the central stations.

The Gulf of Tehuantepec marks a major change in trench configuration and possibly in age. NW. of Tehuantepec the flat trench bottom developed in most places suggests a greater age. SE. of the gulf the deep V-shaped trench, with thicker crustal layers but very little fill, borders a volcanically active coast. The zone of ridge-and-trough topography trending SW. from Tehuantepec may be another evidence of this boundary.--Auth.

3-2191. Shor, George G., Jr., and Robert L. Fisher. MIDDLE AMERICA TRENCH: SEISMIC-REFRACTION STUDIES: Geol. Soc. America, Bull., v. 72, no. 5, p. 721-729, 8 figs., 3 tables, May 1961, 9 refs.

Seismic-refraction profiles in the Middle America trench show that the main crustal layer ranges from normal oceanic thickness (about 5 km.) to half again as thick. Sediments are thicker than in the Pacific basin. Because of the increased depth of water and sediment at all stations and thickening of the main crustal layer at some stations, the M discontinuity bows down beneath the trench. At the outer edge of the continental shelf near Guatemala, the water is replaced by sediments and rocks which may be either consolidated sediments or volcanic rocks; the M discontinuity is at little greater depth than beneath the trench.--Auth.

3-2192. Neilson, James M. GEOMORPHOLOGY AND GLACIAL GEOLOGY OF SOUTHWESTERN BAFFIN ISLAND, DISTRICT OF FRANKLIN, NORTHWEST TERRITORIES, CANADA (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 21. Other Subjects, p. 90-104, 8 illus., 2 maps, 1960) 13 refs.

An account of the geomorphology and glacial geology of southwestern Baffin Island. The main physiographic features are described, and the stratigraphic distribution of the rocks is considered in general terms. With a new K^{40}-A^{40} age determination, the relative ages of the Precambrian rocks are discussed. The effects of Pleistocene glacial erosion and deposition are described together with the effects of deglaciation which resulted in features indicative of both emergence and submergence. The geomorphic processes active in this arctic region produce conspicuous examples of frost action and surface weathering, fluvial and lacustrine phenomena, mass wasting, patterned ground, etc.; these are described in detail. --Auth.

3-2193. Suslov, S. P. PHYSICAL GEOGRAPHY OF ASIATIC RUSSIA. Translated from the Russian by Noah D. Gershevsky and edited by Joseph E. Williams: 594 p., 50 maps, 168 figs. incl. illus., diags., San Francisco, W. H. Freeman, 1961, 55 refs.

Because this book on the physical geography of Siberia and Central Asia was intended for senior geography students in the state universities and teacher-training schools of the U.S.S.R., the manner in which the facts are presented has been determined

by the systematic method of teaching geography in the Soviet schools.

Each geographic region is considered to be a basic unit and is studied in terms of its historical development and its place in the present-day landscape. Only enough Tertiary geologic history is given to provide a background for a detailed study of a region's development in the Quaternary period. In other words, historical geology is discussed only where it has influenced the historical development of the contemporary landscape. Each region is examined as an integral part of a larger area (e.g., of western Siberia, eastern Siberia, or the Far East), and at the same time is treated as a single entity composed of coordinated parts – zones, subzones, districts, and landscapes.

The boundaries of major and minor geographic regions are carefully drawn. Since landscapes are considered to be a result of later developments in the life of a geographic region they are discussed after the description of each region or zone. All geographic divisions are examined genetically and are described geologically and geographically, with emphasis on their modern structure, seasonal changes, and reconstruction in relation to the economy. Animals and plants are considered, whenever possible, according to their biocoenoses. Attention is given to ecological factors, seasonal change of vegetation, and the yearly cycle of animal life.

Independent geologic, geomorphologic, climatic, geobotanic, or other explications are not provided; rather, factual data from related sciences are regarded as indissoluble components of the geographic whole. The order of presentation of the material in each chapter is not always the same, and the size of the parts, chapters, and sections varies since individual elements play different roles in different regions. For example, Chap. 4 is concerned entirely with the physical geography of eastern Siberia, but Chap. 10 covers all the aspects of a smaller geographic area.--Auth. pref.

The 15 chapters are divided into 4 parts. Pt. 1, Western Siberia, covers western Siberian lowland; Altai, and Salair-Kuznetsk mountain region and Kuznetsk basin. Pt. 2, Eastern Siberia, covers eastern Siberia; eastern Siberia arctic region; central Siberia; northeastern Siberia; Sayan mountains, Tannu-Ola range, and Tuva basin; and Baikalia. Pt. 3, Far East, covers Amur-Primorski region; northwestern coast of the sea of Okhotsk and Sakhalin island; and Kamchatka-Kurile volcanic region. Pt. 4, Central Asia, covers semidesert region of central Asia; desert region of central Asia; and mountain region of central Asia.

3. STRUCTURAL GEOLOGY

See also: Areal and Regional Geology 3-2157, 3-2158; Geomorphology 3-2177, 3-2190, 3-2191; Stratigraphy 3-2217, 3-2220; Geophysics 3-2292, 3-2308; Igneous and Metamorphic Petrology 3-2363; Fuels 3-2431; Engineering Geology 3-2448.

3-2194. Reisner, G. I. CONSTRUCTION OF GRADIENT MAPS OF THE RATE OF VERTICAL TECTONIC MOVEMENTS OF THE CRUST, BASED ON AN EXAMPLE FROM THE NORTHERN TIEN-SHAN: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 9, p. 873-876, 2 maps, 2 tables, pub. 1961, 6 refs.

Discusses methods of preparing gradient maps of the rate of vertical tectonic movements from geological data.

The gradient maps of the rate of vertical tectonic movements are much to be preferred over the existing schematic presentations of the distribution of higher gradient belts. They give a quantitative characterization of the vertical tectonic movements at each point of the entire investigated area, and they provide also a more complete over-all picture of the gradient distribution in plan view. This again allows an easier comparison of seismological and geological data for the establishing of seismic regional subdivisions.--From auth., p. 873, 876.

3-2195. Beloussov, V. V. EXPERIMENTAL GEOLOGY: Sci. American, v. 204, no. 2, p. 96-104, 106, illus., Feb. 1961.

After a summary of historical approaches to tectonic model studies, the efforts of Soviet scientists are presented. Special emphasis is put on problems of physical parameters like plasticity, elasticity, and "solidity" to conform with scale changes in time and distance. Details of scale reduction for a salt dome model are given, and fault and fold models are described. Even transparent models, viewed by polarized light, have been used for stress analysis.

Conclusions resulting from the models are compared to field studies, especially with regard to salt domes, mud volcanoes, folding – both simple and complex, and faulting of various sorts, especially giant scalloped faults, and longitudinal and cross faults.--R. F. McAllister.

3-2196. Ramberg, Hans. RELATIONSHIP BETWEEN CONCENTRIC LONGITUDINAL STRAIN AND CONCENTRIC SHEARING DURING FOLDING OF HOMOGENEOUS SHEETS OF ROCKS: Am Jour. Sci., v. 259, no. 5, p. 382-390, 2 figs., pl., May 1961, 5 refs.

In a folded sheet of rock which is homogeneous, isotropic, and behaves as a Newtonian medium, concentric shearing strain in the flanks, γ_{max}, is shown to be related to maximum concentric longitudinal strains in the crest, ε_{max}, thus $\gamma_{max}/\varepsilon_{max} = 2\pi D/S$. D is thickness of layer and S length of arc of one wave.

Unless thickness is larger than about one-third of the length of arc, diagonal shearing strain in the crests is shown to be greater than maximum concentric shearing strain in the flanks. For folded sheet with D/S less than one-third, one should therefore expect to find traces in the form of fractures, slip planes, etc., in diagonal directions in the crests before such traces are detectable as concentric planes in the flanks.

If the folded layer is predisposed to concentric shearing by microscopic lamination or schistosity, the relation between maximum concentric shearing strain and maximum concentric longitudinal strain is found to be

$$\frac{\gamma_{max}}{\varepsilon_{max}} = \frac{2D\pi\mu_c}{S\mu_f}$$

where μ_c is "effective viscosity coefficient" for concentric longitudinal strain and μ_f is "effective viscosity coefficient" for concentric shearing strain.

The relationships above refer to folds with small amplitude/wave length ratio.--Auth.

3-2197. Scheidegger, Adrian E. FAULTS AND EARTHQUAKES: Can. Oil & Gas Industries, v. 14, no. 4, p. 33-42, 14 figs., Apr. 1961, 10 refs.

Stresses are endogenetic processes which can result in the entrapment of oil by the deformation of the earth's crust. The processes causing deformation are called "theories of orogenesis" and have been placed in such categories as 1) the contraction theory - the solid crust shrivelled as the earth cooled and contracted, 2) polar wandering - as the poles wandered, differences in the polar and equatorial diameters created shear stresses, and 3) convection and continental drift - internal thermal currents due to radioactive decay creates convection currents, the drag of which caused the continents to move, resulting in crumpling on one side.

The actual stresses can be visualized from field examination on mountains, rift zones, submarine fracture patterns, etc. Fracture formation in oil wells might be used to interpret the geological stress state. Earthquakes are the result of stress; the focus is characterized by the fault and the auxiliary planes which are orthogonal to each other, a relationship from which can be determined the type of fault - transcurrent, normal, or reverse - by a least square solution. If sufficient fault plane solutions are available, calculations can be made on the tectonic stresses for the particular area. The null axes of earthquakes can be used to determine the large-scale tectonics of an area.--C. G. Winder.

3-2198. Crowell, John C. THE SAN ANDREAS FAULT IN SOUTHERN CALIFORNIA (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 18. Structure of the Earth's Crust and Deformation of Rocks, p. 45-52, fig., 1960) 19 refs.

In southern California the San Andreas fault is marked by great crushed zones, and opposing terranes across the fault differ in character and age. The juxtaposition of these different rocks can be explained only by great strike-slip. The fault system, still vigorous, has been intermittently active throughout the Cenozoic, as shown by the greater relative displacement of successively older rock units and by the local marking out of basins of deposition by the fault.

Proceeding back through time from the present, correlations suggest displacements as follows. Historic California earthquakes have resulted in strike-slip, such as the 21 ft. (6.3 m.) during the San Francisco earthquake of 1906. In southern California, Pleistocene terrace deposits show from 3 to 10 mi. (4.8-16 km.) displacement, Pliocene rocks perhaps 35 mi. (56 km.), Miocene from 30 to 65 (48-104 km.), Oligocene about 175 (280 km.), and older rocks perhaps still more. In reviewing these displacements, the work of M. L. Hill, T. W. Dibblee, L. F. Noble, J. C. Crowell, and others is called on. New evidence for about 160 mi. (260 km.) of combined displacement on the San Gabriel fault, 30 mi. (48 km.), and the San Andreas, 130 mi. (210 km.), is presented here, based on the apparent offset of basement terranes. The reliability and significance of these displacements, which seem to be characteristic of tectonic deformation in California, as elsewhere, must be evaluated in a satisfactory theory of orogeny.--Auth.

3-2199. Foose, Richard M. SECONDARY STRUCTURES ASSOCIATED WITH VERTICAL UPLIFT IN THE BEARTOOTH MOUNTAINS, MONTANA (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 18. Structure of the Earth's Crust and Deformation of Rocks, p. 53-61, 3 figs., 1960) 15 refs.

The Beartooth Mountains are a great rectangular block of the earth's crust, topographically and structurally elevated above adjacent basins in the Middle Rocky Mountains. High angle and thrust faults bound the mountain block on all sides, though exact structural relations are locally obscured by Tertiary volcanics.

The southern corner of the Beartooth block is made by 2 intersecting vertical faults that terminate at their junction. Thus, the raised corner is in a fixed position; there is no horizontal transport of the raised block over the adjacent Bighorn basin. The northwestern corner of the block has a similar structural setting, and horizontal transport is minimal.

At the NE. corner of the mountain block the structural relief is between 15,000 and 20,000 ft. At this corner the unconfined mountain mass has moved outward over the adjacent basin as much as 10,000 ft. At and near the block corner where there has been maximum horizontal transport there are a number of secondary structures that characterize the tectonic history of the block. These include bent high angle faults, tear faults and imbrication that make the local geologic detail complex. About 10 mi. toward the vertically fixed southern and northwestern corners of the block there are very large thrusts and lateral shear structures in the sedimentary rocks created by the motion of the massive block northeastward toward the unconfined corner.

Interpretation of these secondary structures affords an opportunity to unravel a major part of the Laramide tectonic history of the Beartooth massif.--Auth.

3-2200. Duska, Leslie. DEPTH OF THE BASAL SHEARING PLANE IN CASES OF SIMPLE CONCENTRIC FOLDING: Alberta Soc. Petroleum Geologists, Jour., v. 9, no. 1, p. 20-24, 3 figs., Jan. 1961, ref.

In the Arctic Islands, Northwest Territories, there are some very regular, parallel anticlines at almost equal intervals, with all the reliefs eroded to a plane. The paper presents a method to compute the depth of the basal shearing plane for these ideal cases of simple concentric folding.--Auth.

3-2201. Craddock, Campbell. THE ORIGIN OF THE LINCOLN FOLD SYSTEM, SOUTHEASTERN NEW MEXICO (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 18. Structure of the Earth's Crust and Deformation of Rocks, p. 34-44, 2 figs., 1960) 23 refs.

Gently eastward-dipping middle Permian strata crop out in a N.-trending belt 50 mi. wide in southeastern New Mexico. Eastward these beds pass below younger Permian and Triassic strata at low elevations. Westward at high elevations they underlie younger Permian to Cretaceous strata lying in a small faulted and intruded structural basin, its center occupied by topographically prominent, unroofed, post-Cretaceous plutons.

These middle Permian strata include 2 formations: the Yeso (1,200 to 1,800 ft. of siltstone, mudstone, limestone, and gypsum) and the overlying, conformable San Andres (1,000 ft. of massive limestone). Regionally the San Andres forms a slightly warped plate dipping eastward about 1°, but locally it is buckled into sharp, narrow folds. These fold axes

form an arcuate pattern, concave toward the intrusive complex to the W. Wherever exposed in valleys, the less competent Yeso formation is strongly folded. Near Lincoln the Yeso exhibits large folds (wave length 500 to 1,000 ft. for 3 mi., but the conformable San Andres is nearly horizontal.

This unusual fold system is believed to be early Tertiary in age. It was formed by eastward gravitational movement of these strata about 3 mi., triggered by temporary doming due to plutonic intrusions to the W.--Auth.

3-2202. Muehlberger, William R. INTERNAL STRUCTURES AND MODE OF UPLIFT OF THE GRAND SALINE SALT DOME, VAN ZANDT COUNTY, TEXAS, UNITED STATES OF AMERICA (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 18. Structure of the Earth's Crust and Deformation of Rocks, p. 28-33, 2 figs., 1960) 9 refs.

The Morton Salt Company's Kleer Mine exposes, over an area 3,000 by 1,800 ft., internal structures in the southern quadrant of the Grand Saline salt dome, 65 mi. east of Dallas, Texas. Layering, believed to be original sedimentary bedding, is outlined by anhydrite-rich bands which appear dark as compared with the nearly pure salt.

Along the southern margin of the mine the layers dip steeply S. parallel to the margin of the dome. Elsewhere the layers form intricate patterns of steeply-plunging nonfaulted shear folds. Attenuation of folds is observed as the dome margin is approached.

Differential uplift on a small scale is demonstrated by closures 10-50 ft. across at several points in the mine. On a larger scale, the entire mine occupies most of a large spine as demonstrated by tracing a clear, coarse-grained zone of salt around 3 sides of the mine. Radical changes in direction of the fold axes along E.-trending lines indicates that the overburden failed along faults and that the dome rose as pencils and spines into local areas of weakness rather than moving uniformly upward as an entity.--Auth.

3-2203. Williams, Howel. VOLCANIC COLLAPSE-BASINS OF LAKES ATITLAN AND AYARZA, GUATEMALA (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 21. Other Subjects, p. 110-118, 4 figs., 1960) 8 refs.

The oval basin of Lake Atitlan, which approximates 100 sq. mi. in extent, is surrounded by a ring-fracture. Most of it is enclosed by fault scarps cut in gently folded late Tertiary lavas, tuffs, and tuffaceous sediments, but on the S. side these are buried by flows from the Quaternary volcano of Atitlan, the vent of which lies on the ring-fracture. The adjacent volcanoes of Toliman and San Pedro lie inside the basin. Growth of these 3 volcanoes dammed drainage to produce the lake.

Atitlan basin is neither a caldera nor a volcano-tectonic sink, as previously supposed. It is a cauldron subsidence caused principally by collapse resulting from subterranean withdrawal of magma, though its southern part may have continued to sink because of Quaternary eruptions. No central volcanoes ever rose above the lake, and the enclosing faults are controlled only slightly by tectonic structures.

Lake Ayarza, on the contrary, is a caldera of Krakatoan type, caused by collapse as a result of colossal eruptions of pumice. The walls consist mainly of Tertiary lavas, but the basin was formed by engulfment of the tops of 2 coalescing Quaternary cones and hence is shaped like the figure 8.--Auth.

3-2204. Shoemaker, Eugene M. PENETRATION MECHANICS OF HIGH VELOCITY METEORITES, ILLUSTRATED BY METEOR CRATER, ARIZONA (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 18. Structure of the Earth's Crust and Deformation of Rocks, p. 418-434, 5 figs., table, 1960) 51 refs.

Studies of craters formed by detonation of nuclear devices at shallow depth in alluvium show that structures of the crater rims are related to the depth of explosion and the yield of the device. The penetration mechanics for Meteor Crater, Arizona, are derived by scaling relationships from the nuclear explosion craters, based on detailed geologic mapping of both types of craters.

A meteorite that strikes the ground at a speed exceeding the acoustic velocity of the rocks propagates a shock wave in the rocks. If the speed of the meteorite also exceeds the acoustic velocity of the meteorite, a shock wave also travels back through the impacting body. At hypersonic velocity an impacting meteorite penetrates the ground by a complex mechanism that includes compression of the target rocks and the meteorite by shock as well as hydrodynamic flow of the compressed material under high pressure and temperature. The depth of penetration of the meteorite, before it loses its integrity as a single body, is a function primarily of the velocity and shape of the meteorite and the densities and equations of state of the meteorite and target. The intensely compressed material then becomes dispersed in a large volume of breccia formed in the expanding shock wave.--Auth.

3-2205. Berthelsen, Asger. AN EXAMPLE OF A STRUCTURAL APPROACH TO THE MIGMATITE PROBLEM (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 14. The Granite-Gneiss Problem, p. 149-157, 3 figs., table, 1960) 9 refs.

A detailed structural analysis has been performed by a team of 12 geologists within an area of about 2,500 sq. km. of the Ketilidian fold belt, SW. Greenland. The investigated region may be divided into a migmatitic infrastructure and a nonmigmatitic, but metamorphosed suprastructure. The infrastructure can be divided into several major lithological units which comprise migmatites, various types of gneisses and intercalations of crystalline schists as garnet-amphibolites and garnet-biotite-schists. One of these gneiss series is characterized by layers and inclusions of a peculiar plagioclase-hornblende rock ("gabbro-anorthosite"). The suprastructure comprises the more or less metamorphosed Sermilik and Arsuk groups. The former is mainly sedimentary, the latter mainly volcanic. Within the infrastructure 3 phases of deformation may be traced: 1) A probable pre-migmatitic deformation causing repetition of the supracrustal rock series by isoclinal folding. 2) A syn-migmatitic phase producing disharmonious major folds of plastic style striking NW. Within these structures, small-scale structures are homologous with large-scale lithological features. Between the second and the third phase are intrusions of dunitic and peridotitic plugs and sills. 3) A complete refolding of older structures. The "arrested" migmatite front was folded and thrown into a struc-

tural unconformity, whereby infra- and supra-rocks of widely different aspects were placed in direct contact. The NE.-directed axes of this phase are typically developed in the suprastructure, but may also be traced in the culminative and depressive regional bending and twisting of the older infrastructure. Where the supratectonics have "worked downwards" complicated small-scale patterns of double folding ("wild migmatites") were formed in the infrastructural rocks. Towards the decline of this phase, a granitic augen-gneiss developed in the border zone between the 2 "Stockwerke."

By elimination of the effects of the youngest superimposed folding a complete lithological conformity emerges between the 2 structural levels – in spite of their great structural disharmony. The migmatite complex was formed therefore at the expense of Ketilidian supracrustal rocks. Large-scale migrations of matter are manifest in the conversion of sheared basaltic pillow lavas into banded gneisses of quartz-dioritic composition.

Only the application of appropriate structural analyses can provide the necessary background for further petrographic studies.--Auth.

3-2206. Gussow, William Carruthers. THE PRE-DEVONIAN UNCONFORMITY IN NORTH AMERICA (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 19. Caledonian Orogeny, p. 158-163, fig., 1960) 20 refs.

Over the past 15 years, field work in Gaspé Peninsula, Quebec; southwestern Ontario; the Hudson Bay lowlands; the western Canada sedimentary basin; and in the foothills and Rocky Mountains of Canada, has demonstrated conclusively the profound pre-Devonian unconformity that is present everywhere in North America at the base of the Devonian. This represents a great lost time interval in the geological record throughout North America and represents a regional unconformity of continental proportions which is considered to have world-wide implications.

In the Rocky Mountains of Canada, there is new evidence of pre-Devonian orogeny. Evidence for the Caledonian orogeny is just as impressive in North America as it is elsewhere.--Auth.

3-2207. Patterson, J. R., and Taras P. Storey. CALEDONIAN EARTH MOVEMENTS IN WESTERN CANADA (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 19. Caledonian Orogeny, p. 150-157, 4 figs., 1960) 14 refs.

In western Canada strata ranging from Lower Devonian to high Upper Devonian rest with distinct unconformity on Precambrian, Cambrian, Ordovician, and Silurian rocks. Lack of recognition of this unconformity is responsible for miscorrelation of Devonian strata with the older systems, obscuring the criteria for recognizing the effects of the Caledonian uplift and orogeny. By erroneously dating the Caledonian movements according to the successively higher Devonian strata above the unconformity it has been said erroneously that these movements persisted as pulses throughout the Devonian. These fallacies collapse in the light of regional stratigraphy, structure, and in some cases metamorphism below the unconformity. Nowhere in western Canada is there evidence of the effects of Caledonian uplift or orogeny within Devonian sediments above this unconformity.--Auth.

3-2208. Norton, Matthew F. APPALACHIAN TECTONICS (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 18. Structure of the Earth's Crust and Deformation of Rocks, p. 69-80, 6 figs., table, 1960) 33 refs.

Appalachian Paleozoic fold axes parallel not only Triassic, but also Paleozoic basement faults. This negates the classic theory that the folds were formed by compression and the faults by later tension in the same direction. Instead, this parallelism and the persistence of individual folds suggests that the sedimentary cover deformation was caused by gravity and triggered into action by fault movement. Appalachian structures appear related to 2 main deformation directions operative at least from Ordovician through Triassic. The predominant direction of basement fracturing, N. 40°-45°E., involves sinistral movement along a right shear and conjugate tension direction. This implies the actual stress was a couple caused by the tendency of the area to the W. to move relatively southwestward. The second major direction of basement faulting, N. 80°-85°E., is also sinistral, and causes offset and rotation of fractures resulting from the first trend. Most horizontal movement in both major directions occurred before sediment deformation. Triassic movements, however, seem to require some horizontal component of stress. The only real differences between Appalachian and other tectonic styles appear to result from size, extent, and relative movement of basement blocks, and thickness and type of sedimentary cover available for deformation.--Auth.

3-2209. Cook, Harold J. NEW CONCEPTS OF LATE TERTIARY MAJOR CRUSTAL DEFORMATIONS IN THE ROCKY MOUNTAIN REGION OF NORTH AMERICA (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 12. Regional Paleogeography, p. 198-212, map., sec., 1960) 132 refs.

Following the major mountain building activities of the Laramide revolution, which ended in mid-Tertiary times and which was characterized by sharp mountain folding (but with mountain bases little above sea level), there followed an enormous epeirogenic uplift of the whole Rocky Mountain region. This raised the whole area massively to as much as a mile or more above where it has rested at the end of the Laramide revolution. This was accompanied by new mountain folding, warping, and faulting, with many local readjustments and echo effects. It began with the Oligocene and reached its climax in late Pliocene time, developing by stages that can be dated by good evidence. This late Tertiary orogeny, which we have called the Rocky evolution, is quite distinct in its genesis from the major compressional activities of the Laramide revolution.

Evidence from original research and from the work and observations of others is cited from structural, stratigraphic, paleontologic, and ecologic sources to help date geomorphologic and ecologic events and patterns of wide significance.

These include faunal migrations and related correlaries, and the location and occurrence of important oil and other mineral deposits among its ramifications, many as yet little studied.--Auth.

3-2210. Thompson, George A. PROBLEM OF LATE CENOZOIC STRUCTURE OF THE BASIN RANGES (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 18. Structure of the Earth's Crust and Deformation of Rocks, p. 62-68, 4 figs., 1960) 14 refs.

The Basin Ranges of W.-central Nevada and adjacent California constitute a structural unit with the Sierra Nevada. This elevated land mass forms a topographic wave with an amplitude of more than 3 km. and a wave length of about 250 km. The topographic upwarp and the superimposed basins and ranges were developed largely during the latter part of the Cenozoic era. Gravity measurements indicate that the topographic swell is isostatically compensated but the measurements neither prove nor disprove compensation of individual basins and ranges.

Study of the horizontal components of regional strain which occurred during the formation of the topographic upwarp shows that the region has expanded laterally roughly 5% or more by deformation along normal faults. This expansion cannot be accounted for by tilting or folding of strata. Simultaneous lateral and vertical expansion by phase change at the M discontinuity could qualitatively account for the deformation but is inadequate quantitatively. A combination of phase change and subcrustal flow, however, does seem adequate to explain the deformation.--Auth.

3-2211. O'Brien, Christian Arthur Edgar. THE STRUCTURAL GEOLOGY OF THE BOULE AND BOSCHE RANGES IN THE CANADIAN ROCKY MOUNTAINS: Geol. Soc. London, Quart. Jour., v. 116, pt. 4, no. 464, p. 409-436, illus. incl. col. geol. map, scale 1:50,000, Dec. 1960.

The paper records the results of geological mapping over the Boule and Bosche ranges which form a part of the Front Ranges and adjacent foothills of the Rocky Mountains of Canada in an area near the Athabaska River valley.

The structure of the area comprises a series of individual thrust-blocks, each successively overlying the contiguous block from SW. to NE. Each block has been subjected to intense folding and faulting. Folding is moderately disharmonic at the surface, with the sedimentary column displaying 3 competent groups separated by incompetent formations with strong tendencies towards plastic deformation.

Near the base of the column is a thick section of chloritic shales of Lower Cambrian age, whose importance is stressed as a potential lubricating medium for the main thrust movements. The possibility of the existence of a plane of décollement in this lubricating medium is discussed, with the attendant suggestion that the Front Ranges may have been pushed northeastwards over a largely unbroken Lower Cambrian and Precambrian basement.--Auth. summ.

3-2212. Eaton, Gordon P., and John L. Rosenfeld. GRAVIMETRIC AND STRUCTURAL INVESTIGATIONS IN CENTRAL CONNECTICUT (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 2. Geological Results of Applied Geochemistry and Geophysics, p. 168-178, 3 figs., 2 tables, 1960) 20 refs.

The Central Lowland of Connecticut is underlain by gently dipping arkosic redbeds and interbedded basalts of Triassic age. It is bounded on the E. by a normal fault of large displacement which separates these rocks from highly metamorphosed Paleozoic and possible Precambrian rocks of the Eastern Highland.

The principal tectonic elements of the area are 1) the asymmetric trough of Triassic sediments and its eastern border fault; 2) a chain of mantled gneiss domes immediately E. of the border fault and a broad synclinorium of metastratified rocks farther E.; 3) regional fracture sets that cut both the Triassic rocks and the pre-Mesozoic metamorphic rocks. A detailed gravimetric investigation was undertaken to determine the approximate structural configuration of the Triassic trough and gneiss dome chain at depth.

The conclusions reached as a result of this study are: 1) The Triassic trough occupies a zone of long-continued local weakness in the crust which was tectonically active before Triassic sedimentation commenced. 2) The trough was molded between 2 quasi-parallel chains of older gneiss domes. 3) The last major deformation in the region consisted of broad crustal warping in which the rocks of both the Lowland and Highland responded as a single unit.--Auth.

3-2213. Sanders, John E. STRUCTURAL HISTORY OF TRIASSIC ROCKS OF THE CONNECTICUT VALLEY BELT AND ITS REGIONAL IMPLICATIONS: New York Acad. Sci., Trans., v. 23, no. 2, p. 119-132, 2 figs., table, Dec. 1960, 37 refs.

The structural history of the Triassic rocks of central Connecticut is based on interpretation of the stratigraphy and present attitudes of the strata. Boulder conglomerates adjacent to the NNE.-SSW.-trending border fault testify to syndepositional movement on the border fault during the upper Triassic. After deposition, the strata were tilted to the ESE. and also warped into a series of anticlines and half basins whose axes strike NW.-SE. and plunge toward the border fault. These warped structures, which involve the underlying pre-Triassic "basement," are limited to elongate blocks that are bounded on each side by a fault; they have also been displaced by another set of faults (lowland fault system) into which have been injected late basaltic dikes.

The Connecticut Valley belt of Triassic rocks ends on the S. in New Haven harbor where the pre-Triassic "basement" surface at the base of the Triassic, dipping steeply ENE., strikes directly into the border fault.

A similar history is indicated for the New York-New Jersey belt of Triassic rocks but with dip of strata toward the NW. into a SE.-dipping border fault. The NW.-dipping New York-New Jersey belt and SE.-dipping Connecticut Valley belt together define a regional arch whose axis crosses western Connecticut.

The New York-New Jersey belt of Triassic rocks ends N. of Stony Point W. of Peekskill, New York, where the pre-Triassic "basement" surface, dipping SW., strikes into the border fault.

The mirror symmetry of the surface of the basement at the southwestern end of the Connecticut Valley belt and northeastern end of the New York-New Jersey belt defines a major NW.-SE.-trending regional anticline whose axis is parallel to those of the other warped structures in the Triassic rocks of both areas and that extends from the border fault in Connecticut to the border fault in southern New York. This Danbury anticline (new name) intersects the NE.-SW.-trending regional arch near Danbury, Connecticut, in an area where positive gravity anomalies of 35 milligals have been found.

The reported occurrence of Triassic rocks in a deep well under the coastal plain cover of Long Island is explained as a remnant of a SE.-dipping belt that lies E. of the NE.-SW.-trending regional arch and SW. of the Danbury anticline. The absence of Triassic rocks under Long Island Sound, indicated by seismic traverses, is explained by the existence

there of the broad crestal area of the Danbury anticline.--Auth. summ.

3-2214. Baadsgaard, Peter H. BARBADOS, W.I.: EXPLORATION RESULTS, 1950-1958 (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 18. Structure of the Earth's Crust and Deformation of Rocks, p. 21-27, 5 figs., 1960) 5 refs.

After much early drilling activity and some oil production by a local company, Gulf entered Barbados in 1950 and later drilled 6 tests, all of which showed some evidence of oil and gas, but no commercial oil production was obtained. The stratigraphic section (excluding the late Coral Rock formation) comprising the clastic Scotland group below and the dominantly pelagic - open sea, but not abyssal - Oceanic group above, is believed to be made up of a number of now superimposed and collectively folded and faulted structural plates representing laterally condensed sedimentary sequences of apparently Paleocene to middle Eocene, and definitely upper Eocene to Miocene ages. However, faunal evidence in the Scotland group is generally weak, the stratigraphic units being essentially lithological. The Joes River "Mudflow" is now thought to represent mobilized shear zones, which, although showing residual stratigraphy, are not considered a distinct formation, and do not show bedding. The structure, both in outcrop and well section is extremely complex, with extensive overturned folds and large isolated blocks of competent formations. A possible explanation of the complicated tectonics is presented.--Auth.

4. STRATIGRAPHY AND HISTORICAL GEOLOGY

See also: Geologic Maps 3-2124; Areal and Regional Geology 3-2144, 3-2145, 3-2151 through 3-2156, 3-2159, 3-2160; Geomorphology 3-2170; Structural Geology 3-2206, 3-2207, 3-2209; Paleontology 3-2264, 3-2268, 3-2271, 3-2282; Mineralogy 3-2337.

3-2215. Wilson, John Andrew. STRATIGRAPHIC PRACTICE IN NORTH AMERICAN VERTEBRATE PALEONTOLOGY (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 22. Proceedings of the International Paleontological Union, p. 102-110, 4 figs., 1960) 6 refs.

The biostratigraphic term "fauna" has been used as equivalent to "zone." Its need arose after the abandonment of the term "zone" by vertebrate paleontologists in North America.

Synchronous events in geologic time were once thought to be recognizable over the whole earth, later over a continent and finally over a sedimentary province. The best paleontologic tools permit the establishment of only approximate synchrony and appeals to type sections, type faunas, or zones or to legislative fiats but do not solve the inherent difficulty of subdividing a continuum.--Auth.

3-2216. Sloss, L.L. CONCEPTS AND APPLICATIONS OF STRATIGRAPHIC FACIES IN NORTH AMERICA (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 12, Regional Paleogeography, p. 7-18, fig., 1960) 18 refs.

The characteristics of the stratigraphy of North American cratonic areas, coupled with the widespread availability of subsurface data, has led to the emergency and application of facies concepts which depart markedly from classic European practice. Differences in approach are noteworthy in the following points: 1) Facies are treated as lateral variants within a defined stratigraphic unit. Facies maps are natural corollaries of this concept. 2) Facies are identified in terms of empirical expressions of sedimentary aspect, with environmental and other interpretations being the product of facies analysis. 3) A stratigraphic unit at any point of observation may reveal a number of separate aspects, leading to the recognition and mapping of several kinds of facies. 4) Facies and facies analysis are not necessarily restricted to time-stratigraphic units and are capable of yielding many interpretations in addition to reconstructions of paleogeography and environment. 5) Emphasis is placed on the numerical expression of sedimentary aspect and the construction of quantitative facies maps, with application of automatic data-processing techniques where such application is justified.

A number of examples are used to illustrate the methods of selection and correlation of stratigraphic units for analysis, the various types of facies maps in current use, objective (statistical) and subjective map analysis, and applications to academic problems and mineral exploration.--Auth.

3-2217. Gastil, Gordon, and others. THE LABRADOR GEOSYNCLINE (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 9. Pre-Cambrian Stratigraphy and Correlations, p. 21-38, 3 figs., table, 1960) 42 refs.

The Labrador geosyncline extends from N. to S. a distance of 700 mi. through the heart of the Labrador peninsula. An extensive search for Fe in this belt during the past 15 years resulted in the geologic mapping of about 60,000 sq. mi. at a scale of 1 mi. to the in. or larger.

Between -2,600 and -1,000 million years this belt underwent at least 3 cycles of sedimentation and orogeny. During the early cycle shale, limestone-dolomite, quartz sandstone, and Fe formation were deposited along a western shoreline on a floor of older Precambrian gneiss. The source land lay to the W., but a chain of volcanic islands existed a short distance offshore. The early orogeny (probably between -1,800 and -1,600 m. y.) folded and metamorphosed the eastern part of the basin but its effects did not extend to the western shoreline.

The second cycle began with the appearance of a major sediment source within the geosyncline, considerably E. of its western margin. Thick sections of conglomerate, arkose, and graywacke accumulated near the source area, while graphitic-pyritic shales were deposited further W. Deposition culminated with the outpouring of thousands of feet of pillow lava and the emplacement of large gabbroic sills. The second orogeny (probably between -1,500 and -1,250 m. y.) deformed and metamorphosed the belt along axes similar to the first, but again the western margin was left unmetamorphosed.

The products of earlier deposition and orogeny are unconformably overlain by conglomerate, quartz sandstone, red-bed rocks, and basalt. Along their southern margin these strata too were involved in a third orogeny which occurred between -1,100 and -900 m. y. and extended across the southern part of

the Labrador geosyncline.

In late Cretaceous time old thrust faults were reopened, a large number of crossfolds were produced, and local lagoon and talus deposition occurred.--Auth.

3-2218. Armstrong, H. S. MARBLES IN THE "ARCHEAN" OF THE SOUTHERN CANADIAN SHIELD (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 9. Pre-Cambrian Stratigraphy and Correlations, p. 7-20, map, 1960) 92 refs.

Contrary to general belief, carbonate rocks of sedimentary origin, although commonly inconspicuous, have been identified in a number of localities among the typical "Archean" rocks of the Superior and Churchill provinces. They have also been recognized in the Kisseynew gneisses of the Churchill province, variously mapped as "Archean" or "Proterozoic."

In the Kisseynew occurrences the marbles are associated with quartzites, paragneisses, and amphibolites. The assemblage (limestone-orthoquartzite) strongly suggests miogeosynclinal deposition. In the "Archean" type occurrences marbles and volcanics (commonly basic) are found in a variety of associations: with or without interbedded quartzites; with black pelites and banded Fe formation. The former may result from volcanic warming or agitation of CO_2-rich waters, or possibly deposition by turbidity currents. The black pelite association is suggestive of deposition in euxinic basins.

Consideration of spatial and lithological relationships suggests the contemporaneity of the Kisseynew gneisses ("Archean" or "Proterozoic") and the Amisk-Missi complex ("Archean") in the Churchill province.

Evidence is adduced to suggest that much of the marble is derived from stromatolitic limestones. Since some of these marbles occur with the oldest rocks of the Canadian Shield, in SE. Manitoba, this indirect evidence of early life is of particular interest.--Auth.

3-2219. Cooper, Byron N. SYSTEMIC BOUNDARIES IN THE APPALACHIANS: Mineral Industries Jour., v. 7, no. 4, p. 5-8, illus., Dec. 1960, 11 refs.

Many systemic boundaries in stratigraphic geology are arbitrary oversimplifications. The poorly defined base of the Cambrian suggests that the Appalachian geosyncline was initiated long before the Cambrian. The characteristics of the following stratigraphic boundaries in the Appalachians are discussed: Cambrian-Precambrian, Cambrian-Ordovician, Ordovician-Silurian, Silurian-Devonian, Devonian-Mississippian, Mississippian-Pennsylvanian. The story of Appalachian unconformities is one of many relatively localized breaks whose corresponding interval is elsewhere marked by sedimentary deposits. Systemic boundaries in the Appalachians are incidental to the complex of events that shaped any one stratigraphic break in any given place.--M. Russell.

3-2220. Wheeler, Harry E. EARLY PALEOZOIC TECTONO-STRATIGRAPHIC PATTERNS IN THE UNITED STATES (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 8. Late Pre-Cambrian and Cambrian Stratigraphy, p. 47-56, 2 figs., 1960) 9 refs.

Shorelines migrated from E., W., and S. across United States and at least southern Canada, commencing in latest Precambrian? (pre-Olenellus), and culminating in Early Ordovician complete continental inundation. Transgressive basal sands characterize the initial phase. These sands accumulated thickly in the miogeosynclines and thinly blanketed the craton. By-passed detrital fines were deposited in the bordering geosynclines where and when subsidence rates permitted. The earliest abundant miogeosynclinal carbonates (Middle and Upper Cambrian) reflect the diminishing shield area and the decreasing subsidence rate, the latter causing by-pass of the detrital fines to the eugeosynclines. Early Ordovician total submergence eliminated the detrital-source, resulting in universal carbonate and silica deposition.

A pre-mid-Ordovician unconformity indicates craton reemergence. Consequent detrital fines were transported to rapidly subsident areas (mostly geosynclinal), while the platform and Cordilleran miogeosyncline were blanketed with quartzose sands. Widespread carbonates in central and western states again indicate complete submergence and detrital-source elimination. The closing phase of this submergent episode was marked by Late Ordovician easterly derived sands from the rising Taconian borderland. By-passed fines spread westward across the craton which was strongly subsident for the first time.

The Cincinnati arch, Ozark dome, "Cascadia," and "Appalachia" (except as ephemeral Taconia) were nonexistent during early Paleozoic time.--Auth.

3-2221. Cowie, J. W. NOTES ON LOWER CAMBRIAN STRATIGRAPHY IN THE BOREAL REGIONS (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 8. Late Pre-Cambrian and Cambrian Stratigraphy, p. 57-63, 2 figs., 1960) 7 refs.

The Cambro-Ordovician rocks of E. Greenland can be compared with the succession of similar age in the NW. Highlands of Scotland; correlations are discussed on the basis of the full descriptions of the E. Greenland region published by the author in a joint paper in 1957, further field-study of the Scottish outcrops, and comparison of specimens obtained in the 2 regions.

The present state of knowledge of the extent and validity of faunal provinces in the Lower Cambrian is surveyed. Occurrences of characteristic Pacific province faunas, which are found in continental North America, are traced northwards and eastwards through arctic Canada, Greenland, Spitzbergen, and NW. Scotland; the contrast of these with Atlantic province faunas leads to the consideration of areas with mixed elements. Lower Cambrian faunas from northern Russia are tentatively related to the over-all boreal connections.--Auth.

3-2222. Lochman-Balk, Christina. UPPER CAMBRIAN-LOWER ORDOVICIAN BOUNDARY IN MONTANA, U. S. A. (In: International Geological Congress. 21st. Copenhagen, 1960. Report, Pt. 8, Late Pre-Cambrian and Cambrian Stratigraphy, p. 40-46, 1960)

In northeastern Montana there are exposed interbedded gray-green shales, pink-buff platy crystalline limestones and thin limestone pebble conglomerates carrying fossils characteristic of North American middle Trempealeauan assemblages. These rocks are conformably overlain by beds of similar lithology in which an early Tremadocian fauna of entirely

different composition occurs. It is impossible to place the Upper Cambrian-Tremadocian boundary on the basis of any lithic feature. It is located arbitrarily in each section depending upon the position of the fossils.

Cores from the Williston basin E. of the outcrop areas show a similar faunal and sedimentary history. In an unchanging succession of intercalated dark green calcareous shales and thin gray crystalline limestones the middle Trempealeauan fauna is immediately overlain by the early Tremadocian assemblage. In spite of the conformability and apparent lithic continuity an important faunal break does occur within these beds.

In the Williston basin a complete Tremadocian succession is present. In central and western Montana subsequent upwarping and erosion removed all Tremadocian and most Upper Cambrian rocks. Upper Trempealeauan faunas are known in Utah. The actual trace of the westward shoaling latest Cambrian shorelines is now lost.--Auth.

3-2223. Wagner, W.R. SUBSURFACE CAMBRO-ORDOVICIAN STRATIGRAPHY OF NORTHWESTERN PENNSYLVANIA AND BORDERING STATES: Pennsylvania Geol. Survey, Prog. Rept. 156, 22 p., chart, sec. (in pocket), 1961, 41 refs.

An attempt is made to reconcile Cambro-Ordovician nomenclatural sequences converging on northwestern Pennsylvania from Ohio, New York, and central Pennsylvania. By means of well-sample studies, radioactivity logs, and pertinent literature, the Cambro-Ordovician strata in subsurface of northwestern Pennsylvania are related to correlative outcrop areas in the Upper Mississippi Valley, in the region S. and SW. of the Adirondacks in New York, and in the Nittany arch area in central Pennsylvania.

Two widespread unconformities interrupt the Cambro-Ordovician succession, one occurring within the Beekmantown group and the other located at the top of the Beekmantown.

The facies relationship between the Theresa and Little Falls formations in western New York is reemphasized, and the Utica shale is considered to be a facies of the upper part of the "Trenton limestone" in northwestern Pennsylvania and northern Ohio.--Auth.

3-2224. Kay, Marshall. CLASSIFICATION OF THE ORDOVICIAN SYSTEM IN NORTH AMERICA (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 7. Ordovician and Silurian Stratigraphy and Correlations, p. 28-33, 1960) 37 refs.

Classifications reflect judgements on completeness of record and complementing relations from faunal and lithic evidence among widely separated sequences. Nomenclature further involves attitudes on magnitudes of time-stratigraphic units and practices regarding priority and revisions.

The system is in North America invariably called Ordovician. European terminology applies to graptolite-bearing sequences; otherwise American terms are used. The lowest series is the Canadian except to a few who classify it as a separate system. Canadian sequences in Vermont, Missouri, and Utah are important standards; recently proposed stages are Gasconadian, Demingian, Jeffersonian, and Cassinian.

The Chazyan, Blackriveran, and Trentonian succeed the Canadian in New York, and are classified as separate series, or as 2 series (Chazyan and Mohawkian) or as one (Champlainian). The Chazyan has Whiterockian, Dayan, Crownian and Valcourian stages, the Blackriveran has Pamelian, Lowvillian and Chaumontian, and the Trentonian has Nealmontian, Shermanian and Pictonian stages. Chazyan-Blackriveran rocks have also been placed in Whiterock, Marmor, Ashby, Porterfield, and Wilderness "stages" that may not be wholly exclusive of one another.

The Cincinnatian series is divided into Edenian, Maysvillian and Richmondian stages, to which some add Gamachian above, and take the Utican (Cobourgian and Collingwoodian) from the Trentonian below.

The Lower Ordovician is generally the Canadian, though Chazyan is sometimes included. Upper Ordovician invariably includes the Cincinnatian, and the Trentonian in varying degrees. The intervening rocks are Middle Ordovician.--Auth.

3-2225. Winder, C.G. PALEOECOLOGICAL INTERPRETATION OF MIDDLE ORDOVICIAN STRATIGRAPHY IN SOUTHERN ONTARIO, CANADA (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 7. Ordovician and Silurian Stratigraphy and Correlations, p. 18-27, 3 figs., 1960) 13 refs.

Middle Ordovician sediments of southern Ontario are fossiliferous limestones, shales, and some sandstones which occur in the same general sequence over a wide area. The maximum thickness, as measured in outcrop, is about 600 ft. The beds have an average dip of 20 ft. per mi.; the area has been glaciated, and individual outcrops are limited vertically and horizontally. The paleoecology of formations as interpreted from rock types and fossils is as follows: 1) The sporadically-occurring red basal clastic is a shoreline deposit of a transgressive sea. 2) The fine-grained limestones of the Black River were deposited in a quiet water, lagoonal environment. 3) The bioclastic limestones of the upper Black River and lower Trenton reflect marine condition of higher energy, that is, the surf zone and above wave base. 4) The limestones and shales of the upper Trenton were deposited in quiet water, normal marine conditions, probably below wave base.

Graditional contacts, overlapping faunal zones, structural relationship on Precambrian inliers, and systematic onlap of ecological niches suggest the entire sequence was deposited in a transgressive sea. All formations are contemporaneous in age.--Auth.

3-2226. Lowell, James D. ORDOVICIAN MIOGEOSYNCLINAL MARGIN IN CENTRAL NEVADA (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 7. Ordovician and Silurian Stratigraphy and Correlations, p. 7-17, map, sec., 1960) 18 refs.

An Ordovician miogeosynclinal sequence in central Nevada E. of a line roughly approximated by 117°W. longitude is dominated by shallow water carbonates with minor shales and quartzites which average about 4,000 ft. (1,220 m.) in thickness and contain a shelly fauna. W. of this line a thicker deeper water eugeosynclinal sequence is characterized by graptolitic shales and siltstones, graywackes, cherts, and volcanic rocks.

A limestone-siltstone-shale facies with a thickness probably about half that of the miogeosynclinal section and with lithic and faunal elements common

to both the miogeosyncline and eugeosyncline is present in a band over 30 mi. (50 km.) wide trending approximately along longitude 117°. At one locality on the eastern side of the band rocks of this facies appear to interfinger with those of the miogeosyncline.

The limestone-siltstone-shale facies is interpreted as being transitional between the miogeosyncline on the E. and the eugeosyncline on the W. and requires that any land barrier between the 2 belts was nonexistent or discontinuous in extent along 117° W. longitude in the region of 38°30' to 39°30' N. latitude. The transitional facies was variable in width and trend as at some localities, presumably in the western part of the band, true miogeosynclinal limestones are interbedded with eugeosynclinal or western transitional facies graywackes and phyllites.--Auth.

3-2227. Pratt, Walden P., and W. R. Jones. MONTOYA DOLOMITE AND FUSSELMAN DOLOMITE IN SILVER CITY REGION, NEW MEXICO: Am. Assoc. Petroleum Geologists, Bull., v. 45, no. 4, p. 484-500, 7 figs., Apr. 1961, 22 refs.

Rocks of the Montoya dolomite of Late Ordovician age and the Fusselman dolomite of Silurian age, exposed in the Silver City region of SW. New Mexico, show marked similarities in lithology, sequence, and thickness to rocks of the same formations as reported farther E. The sections in the Silver City region, described here in detail for the first time, are at Bear Mountain, NW. of Silver City; at Lone Mountain, SE. of Silver City; and near Georgetown, NE. of Silver City. The Montoya dolomite is divisible into the same 4 units recognized farther E. in New Mexico and Texas, and the same names are applied to them: from the base up they are the Cable Canyon sandstone member, 11-28 ft. of coarse-grained dolomitic sandstone; the Upham member, 52-91 ft. of massive dolomite; the Aleman cherty member, about 75 ft. of distinctive interlaminated dolomite and chert; and the Cutter member, about 200 ft. of massive dolomite. The Cutter member is separated by a generally sharp and distinct lithologic break from the overlying Fusselman dolomite, which is composed of about 100-300 ft. of gray massive dolomite. The contact is marked by 2 lithologic contrasts: the Cutter is light gray and dense, and the Fusselman dark gray and vuggy. Fossils collected from the Cutter member at Bear Mountain are of Late Ordovician age. Pentameroid brachiopods near the middle of the Fusselman dolomite in its thickest occurrence - at Lone Mountain - are of Middle or Late Silurian age, but corals near the base of the Fusselman suggest that the lower part may be of Late Ordovician age.

The subdivision and nomenclature of the Montoya and Fusselman have had an involved history since the 2 formations were originally differentiated and named by Richardson in 1908. The major developments in this history, especially those since Kelley and Silver's work in 1952, are reviewed and are summarized diagrammatically, in order to provide a background for the discussion of the Montoya and Fusselman at Silver City.

Most workers have now accepted Kelley and Silver's proposal to raise the Montoya to group status and to consider its subdivisions, which are valid lithogenetic units, as formations. Reference to the Montoya as a formation in this paper reflects the current usage of the U. S. Geological Survey but does not preclude group status of the Montoya in areas where its component members are so exposed as to fulfill the other requirement of a formation, that of mappability.--Auth.

3-2228. Lowry, Wallace D. RELATIONSHIP BETWEEN TECTONISM AND SEDIMENTATION IN EARLY SILURIAN TIME IN VIRGINIA: Mineral Industries Jour., v. 7, no. 3, p. 1-7, 5 illus., 3 maps, table, Sept. 1960, 17 refs.

Whether or not commercial concentrations of hydrocarbons exist in the sandstones of the folded Appalachians depends on many factors, of which some of the most significant were in effect at the time of deposition. The structural development and conditions of sedimentation of Silurian sandstones in the Salem and Massanutten synclines in western Virginia are reviewed and tentative interpretations made of the geologic history of the area. The presence, and paleoecologic significance, of such features as Scolithus tubes, carbonized eurypterid remains, bentonite, and ripple marks are discussed.--M. Russell.

3-2229. Alling, Harold L., and Louis I. Briggs, Jr. STRATIGRAPHY OF UPPER SILURIAN CAYUGAN EVAPORITES: Am. Assoc. Petroleum Geologists, Bull., v. 45, no. 4, p. 515-547, 12 figs., 3 tables, Apr. 1961, 96 refs.

The stratigraphy of the Cayugan series strongly contrasts classical terminology of the basin margins with subsurface relationships of the basin centers. Both lithofacies and paleontological facies are sharply defined and narrowly restricted so that the few outcrops in the basin margin carbonate facies serve poorly to define a proper framework for Cayugan stratigraphy. Basinal rocks are exposed only in New York state and in the Appalachian fold-belt in Pennsylvania, Maryland, and Virginia where the rocks are largely atypical of the bulk of the Cayugan series.

A review of the evolution of Cayugan stratigraphic terminology, and the nature and distribution of the faunas demonstrates the provincial nature of knowledge concerning correlation among the regions of classical study. A different stratigraphic terminology is used in New York, Pennsylvania-Maryland, Ohio, Indiana, Wisconsin, and Michigan-Ontario. In most regions the terminology of the basin margins is inappropriate for the basin centers. Moreover in the faunas reported, out of a total of 243 species, 199 (82%) are reported from only 1 locality, and 225 (93%) are reported from 1 or 2 localities.

To solve some of these problems a regional framework of sedimentation is established so that there can be a standard of reference within which stratigraphic classification and correlation over the entire Cayugan depositional basin can be made. The framework of sedimentation establishes general stratigraphic relations between disconnected outcrops, outcrop and subsurface, and subsurface units within and between basins. It is prescribed from regional lithofacies analyses of the distribution of evaporite rock types, limestone-dolomite relations, terrigenous detrital debris, and thicknesses of rock units.

The sedimentary framework for Cayugan rocks involves the development and growth of Niagaran reef platforms around the Michigan and Ohio basins which prevented free interchange of oceanic brine between the open sea and the basin, and which formed the ultimate control on subsequent evaporite deposition. In the eastern part of the Appalachian basin evaporites were deposited in New York and northern Pennsylvania while open marine limestone and shale were being deposited in southern Pennsylvania and Maryland in the Wills Creek-Tonoloway sea. Oceanic brine flow between the southern open ocean and the northern evaporite basin was restricted by the distal

end of the Bloomsburg-Vernon delta complex, deposited by westward flowing streams carrying red terrigenous debris onto the eastern shelf of the Appalachian basin.--Auth.

3-2230. Crickmay, C.H. THE MISINTERPRETED MIDDLE DEVONIAN OF SASKATCHEWAN: Alberta Soc. Petroleum Geologists, Jour., v. 9, no. 1, p. 10-14, Jan. 1961, 9 refs.

There appears to be a discrepancy in the prevailing correlation of Saskatchewan Middle Devonian. Two views on this have been put forward: Mitchell in 1951 correlated with the Winnipegosis formation a certain subsurface interval that Baillie in 1953 attempted to correlate with Dawson Bay formation. Evidence is reviewed, and this leads to the conclusion that the neglected Mitchell view is the more accurate one.--Auth.

3-2231. Bergenback, R.E., and Robert L. Wilson. EARLY PENNSYLVANIAN SEDIMENTATION IN SOUTHEASTERN KENTUCKY AND NORTHERN TENNESSEE: Am. Assoc. Petroleum Geologists, Bull., v. 45, no. 4, p. 501-514, 8 figs., Apr. 1961, 19 refs.

An erosional unconformity separates rocks of Pennsylvanian age from underlying rocks of Mississippian age in a part of the Cumberland Plateau in northern Tennessee and southeastern Kentucky. This erosion surface controlled deposition of the overlapping Pennsylvanian sediments and accounts for the discontinuous nature of the sedimentary units. Presumably overlap advanced from the S. and E. In this area, structural disturbance is at a minimum, except for broad uplift and warping. Minor slumping was observed near the base of the Pennsylvanian.--Auth.

3-2232. McGugan, Alan, and June E. Rapson. STRATIGRAPHY OF THE ROCKY MOUNTAIN GROUP (PERMO-CARBONIFEROUS) BANFF AREA, ALBERTA: Alberta Soc. Petroleum Geologists, Jour., v. 9, no. 3, p. 73-106, 7 figs., March 1961, 40 refs.

The Rocky Mountain group is divided into 3 formations. From the top down these are: the Ishbel formation (new name), the Kananaskis formation (new name), and the Tunnel Mountain formation (restricted) which includes Tunnel Mountain clastics only. The Ishbel and Kananaskis formations together equal approximately type Norquay formation and the Norquay formation of most authors, excepting Raasch at Highwood Pass. Significant stratigraphic breaks separate the above formations which are distinct lithologic entities, themselves containing diasterns and condensed sequences. The Ishbel formation consists of a chert member overlying dark cherty, sometimes phosphatic, quartzitic siltstones with rhythmically interbedded shaly siltstones; the top chert member contains Helicoprion Karpinsky and is probably middle Permian in age. The lower part contains sponge spicules, rare sponges, possible algae, Cancellophycid markings, and occasional pelecypods, and may also be Permian in age. In eastern sections the Ishbel formation is either absent or is represented by conglomeratic remnants due mainly to post-Paleozoic erosion.

The Kananaskis formation consists of silty dolomites with chert breccias and nodular and bedded cherts which contain the early Middle Pennsylvanian fauna Profusulinella, Pseudostaffella, Eostaffella, Plagioglypta, Bellerophon, and Ascopora; Megalodon occurs locally in the E.; its strong buttressed shell suggests a coastline environment. The Kananaskis formation is thin and condensed in easterly sections owing to a combination of depositional factors and erosion of the upper beds. The formation is absent in the NW. at Mt. Ishbel, where the Ishbel formation rests on the irregular surface of the Tunnel Mountain formation. Both the Kananaskis and Ishbel formations are absent in the subsurface further E.

The Tunnel Mountain formation (restricted) consists of brown-weathering cliff-forming dolomitic siltstones and sandstones with some bedded and nodular chert. Colored beds low in the formation equate to the Todhunter member. Occasional brachiopod beds with Orbiculoidea, Spirifer matheri, Composita, Cleiothyridina, and Leiorhynchus indicate a late Chesteran to early Pennsylvanian age. The "Storm Creek formation" is homotaxial and largely contemporaneous with (and the lithologic equivalent of) the Tunnel Mountain formation (restricted). The term "Storm Creek formation" is considered superfluous. Tunnel Mountain clastics overlie bioclastic Etherington formation (Meramec and Chester) carbonates of the Rundle group, but the facies relationships of these lithic elements require detailed investigation, because their development is apparently diachronous.--Auth.

3-2233. Nelson, Samuel J. PERMO-CARBONIFEROUS OF THE NORTHERN YUKON TERRITORY: Alberta Soc. Petroleum Geologists, Jour., v. 9, no. 1, p. 1-9, fig., 4 pls., Jan. 1961, 3 refs.

The Permo-Carboniferous succession of the northern Yukon Territory is outlined, and index brachiopods, diagnostic for certain of the horizons, are described and figured. A tentative formational nomenclature, based partly on the Alaskan succession, is recommended. In ascending order, rock units are the Calico Bluff formation of Upper Mississippian age, the lower Limestone unit of Upper Pennsylvanian(?) age, the middle Recessive unit of Wolfcampian (Early Permian), and the Tahkandit formation of Leonardian (early middle Permian) age.--Auth.

3-2234. Ham, William E. MIDDLE PERMIAN EVAPORITES IN SOUTHWESTERN OKLAHOMA (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 12. Regional Paleogeography, p. 138-151, 7 figs., 1960) 14 refs.

The 2 thickest outcrop sections of evaporites in the Midcontinent region of the United States are in the Blaine and Cloud Chief formations of southwestern Oklahoma. Each is composed mainly of gypsum at the outcrop and of anhydrite in subsurface.

The earlier sequence is the Blaine, of late Leonardian or early Guadalupean age. It has a maximum thickness of 250 ft. and consists of 4 principal cycles. Each cycle is a 3-fold division beginning with dolomite less than 5 ft. thick, continuing upward with white gypsum normally 15-30 ft. thick, and ending with reddish-brown shale 10-30 ft. thick.

The upper half of the Blaine formation is 90 ft. thick and is made up of massive gypsum containing as many as 4 thin dolomite beds but practically no shales, thus representing a composite of several incomplete normal cycles. Northward in subsurface this evaporite unit grades into nearly pure halite.

Four hundred feet above the Blaine is the thickest single evaporite body in the Midcontinent region. It is in the lower part of the Cloud Chief formation, of

probable late Guadalupean age, and consists of gypsum and anhydrite 120 ft. thick with no interbedded shale or dolomite. Extensive core drilling has shown that the Cloud Chief evaporite body is massive and noncyclic. By Cloud Chief time the position of the evaporite basin had shifted markedly eastward, as it was then situated over the shoreward or clastic facies of the Blaine. The Cloud Chief gypsum also is noteworthy for containing marginal tongues of Sr minerals, chiefly celestite, and for containing in the massive gypsum a few small nodules of the borate mineral probertite.--Auth.

3-2235. Loranger, D. M. JURASSIC-CRETACEOUS BOUNDARY IN WESTERN CANADA (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 12. Regional Paleogeography, p. 170-177, 6 pls., 1960) 18 refs.

The contact between the Jurassic and the Cretaceous in western Canada is difficult to define due to the preponderant continental facies, incomplete eroded sections, and recurrent diastrophic activity.

Outcrop sections in the Rocky Mountains which are accessible by helicopter have provided approximately 1,600 ft. of Tithonian sediments within a depositional sequence ranging from late Kimmeridgian into Aptian time. This is believed to be the first complete or almost complete section found and described in western Canada that shows the transition from the Jurassic into the Cretaceous.

A series of paleogeographic maps illustrating the history of this area are presented in this study. The complex stratigraphic relationship of the mountain sections to the fragmentary plains record is shown by cross-sections. Similarities and affinities to the European and Eurasian microfauna are briefly discussed with supporting evidence from megafossil, paleobotanical, and petrographic studies.

On these criteria a position for the Jurassic-Cretaceous contact is suggested which will aid in the preparation of more accurate paleogeographic maps. Locally it may be applied in petroleum exploration.--Auth.

3-2236. Stott, Donald F. SUMMARY ACCOUNT OF THE CRETACEOUS ALBERTA GROUP AND EQUIVALENT ROCKS, ROCKY MOUNTAIN FOOTHILLS, ALBERTA: Canada, Geol. Survey, Paper 61-2, 34 p., secs. (in pocket), chart (in pocket), 1961, 20 refs.

The Alberta group and equivalent rocks comprise a sequence of shales and sandstones, predominantly of marine origin. The Blackstone, Cardium, and Wapiabi formations, for which type sections are defined, compose the Alberta group. The Smoky group, equivalent in part to the Alberta group, contains the Kaskapau, Cardium, and Wapiabi formations. Upper Fort St. John shales and the Dunvegan formation are considered equivalent to part of the Blackstone. Members within the formations have been named and defined with type sections.

This Cretaceous sequence contains rocks that range in age from the late Albian Neogastroplites zone to the Campanian Scaphites hippocrepis zone, or later. Fossils are correlated with standard zones of the western interior.

This account is intended to make available some of the more important conclusions contained in Canada, Geol. Survey, Mem. 317 (in press).--Auth.

3-2237. Weimer, Robert J., and John D. Haun. CRETACEOUS STRATIGRAPHY, ROCKY MOUNTAIN REGION, U. S. A. (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 12. Regional Paleogeography, p. 178-184, 5 figs., 1960) 3 refs.

Lower Cretaceous marine sandstone and shales (Dakota group) intertongue with underlying, nonmarine sandstones and variegated shales (Morrison formation). The boundary between Upper and Lower Cretaceous is at the top of the marine Mowry shale (late Albian), marked by the Clay Spur bentonite bed. Dakota sediments were deposited in a sea that advanced from the N., and thus the basal marine sediments become younger in a southerly direction. Marine shales of the Thermopolis and overlying Mowry and Graneros formations (1,000 ft. thick) to the N. were deposited contemporaneously with sandstones of the Dakota group farther S. (100 to 500 ft. thick). Over most of the region the Dakota group is Early Cretaceous, but in the S., the upper part is Late Cretaceous.

By Late Cretaceous the seaway extended from the Arctic to the Gulf of Mexico. Sediments were derived from a land mass to the W. The dominant sedimentary pattern of the Upper Cretaceous is deposition during the regression of the strand line from W. to E. The marine Benton group, Niobrara limestone, and Pierre shale to the E. (4,000 to 7,000 ft. thick) were deposited contemporaneously with nonmarine Mesaverde and other sediments to the W. (over 15,000 ft. thick). The eastern regression of the strand line was periodically broken by sharp transgressions resulting in the intertonguing of gray marine shale, tan massive transitional sandstone and nonmarine coal-bearing gray clay and tan lenticular sandstone. The Upper Cretaceous rests conformably on the Lower Cretaceous and is overlain unconformably by the Tertiary.--Auth.

3-2238. Eicher, Don L. STRATIGRAPHY AND MICROPALEONTOLOGY OF THE THERMOPOLIS SHALE: Yale Univ., Peabody Mus. Nat. History, Bull. 15, 126 p., 12 figs., 6 pls., 2 tables, 1960, 74 refs.

In the Big Horn basin of Wyoming, the Thermopolis (Lower Cretaceous) of U. S. Geological Survey usage consists of 3 mappable units: a lower sequence of black shale and prominent siltstones, the Muddy sandstone, and an upper sequence of black shale and a few bentonites. This paper restricts the term "Thermopolis shale" to only the lowest of these 3 units in conformity with local usage, proposes the new name Shell Creek shale for the upper unit, and recognizes all 3, the Thermopolis, the Muddy, and the Shell Creek, as formations.

In the Big Horn basin, the restricted Thermopolis shale consists of 4 informal members: the rusty beds at the base, a lower black shale, a thin silty shale, and an upper black shale. The uppermost few feet of the underlying Cloverly formation immediately beneath the contact with the rusty beds commonly contain tiny siderite spherulites which weather to iron oxide. Identical spherulites occur regionally at a similar stratigraphic position; they formed in environments accompanying the initial transgression of the Cretaceous sea.

Stratigraphic evidence indicates that the 3 lower members of the Thermopolis were deposited in an arm of the boreal sea which extended deep into the western interior. The upper shale of the Thermopolis contains 24 species of arenaceous Foraminifera; 5 of these are new, and the remainder include some of the Gulf Coastal province and others of the boreal

province, indicating a joining of the 2 seas. For the first time, an interior seaway extended the length of the North American continent. The limited number of kinds of Foraminifera, as well as molluscs, in the seaway was caused by low salinity. The 2 distinct biofacies in the seaway may also have resulted from differing salinities. A paucity of individuals in some marginal areas of the seaway resulted from a lack of O on the sea floor.

The Muddy sandstone locally consists predominantly of shale and siltstone. In spite of great lateral variations in thickness, in sequence, and in rock type, the Muddy is a laterally persistent, widespread unit which occupies just one stratigraphic interval and which records a single depositional episode. It was deposited over a large area in a variety of local, very brackish, extremely shallow-water environments.

The Shell Creek shale represents renewed transgression of the boreal sea. It contains a new radiolarian species and 12 species of arenaceous Foraminifera; 4 are new and the remainder are known only from the boreal province; 3 also occur in the Thermopolis. The depositional environment was probably similar to that of the upper shale of the Thermopolis. Its contact with the overlying siliceous Mowry shale is laterally persistent; the 2 units are not facies of one another. S. and E. of the Big Horn basin, the Shell Creek shale thins greatly and has not been mapped, although it can be distinguished in good exposures and on electric logs. In southern Wyoming, it thins out and is overlapped by the siliceous Mowry shale.--Auth.

3-2239. Perkins, Bob F. BIOSTRATIGRAPHIC STUDIES IN THE COMANCHE (CRETACEOUS) SERIES OF NORTHERN MEXICO AND TEXAS: Geol. Soc. America, Mem. 83, 138 p., 26 figs., 34 pls. incl. 3 col. geol. maps, 2 charts (in pocket), 2 tables, 1960, 148 refs.

The biostratigraphic relationships of the Aurora limestone in the Sierra de Tlahualilo of southwestern Coahuila to the type Aurora near Ojinaga, Chihuahua, and to the type Lower Cretaceous (Comanche) series of northern Texas are discussed.

Stratigraphic sections of the Fredericksburg and Washita groups in the Fort Worth-Weatherford area of N. Texas are redescribed. The following stratigraphic nomenclatural revisions are proposed: 1) the division of the Goodland formation (Fredericksburg group) into 2 members of which the lower is designated the Marys Creek marl member (new name) and the upper the Benbrook limestone member (new name); and 2) the use of the name "Denison formation" to include the units previously referred to in the Fort Worth-Weatherford area as the Denton, Weno, Pawpaw, Main Street, and Grayson formations and here considered members. Based on the author's collections, faunal lists of the larger invertebrate fossils for each formation and member are given, and the useful zonal guide fossils are indicated. Twelve new species of pelecypods from the area are described.

A fauna of 45 species of larger invertebrates from the upper member of the Aurora limestone of the Sierra de Tlahualilo is described. Of this fauna: 27 species are identified and 5 are compared with species known from the Texas Comanchean; 2 are identified with species previously known from the Mexican Cretaceous; 6 are described as new species; and 6 are given generic assignments only. On the basis of the stratigraphic ranges of the Texan and Mexican species with which the Aurora forms are identified and the ranges of the Texan and Mexican species allied to the new species from the Aurora, it is concluded that the upper member of the Aurora limestone in the Sierra de Tlahualilo should be correlated with the Washita group of Texas. The lower part of the member is correlated with the Fort Worth limestone, and the upper part of the member is correlated with the lowermost part of the Grayson marl. The base of the Aurora limestone is tentatively correlated with the Walnut marl.

This correlation indicates a late Albian to possibly an early Cenomanian age for the upper member of the Aurora limestone in the area studied. Elsewhere in northern Mexico the formation has been determined as ranging from early to middle Albian in age and only at the type area has the upper part of the limestone been considered as young as latest Albian or possibly early Cenomanian. On the basis of these correlations it appears that the environment responsible for the origin of the Aurora limestone did not exist everywhere in northern Mexico at the same time nor did it persist for an equally long period at every place in the region.

The Aurora limestone is interpreted as a formation of epineritic origin deposited far from any source of terrigenous clastics as indicated by the fauna and by the almost complete absence of terrigenous material within this unit. This origin differs from that of the Fredericksburg and Washita groups in N. Texas where the strata of these groups are principally epineritic and infraneritic in origin as shown by the faunas and the abundance of fine-grained terrigenous clastic rocks throughout the section.--Auth.

3-2240. Jeletzky, J. A. YOUNGEST MARINE ROCKS IN WESTERN INTERIOR OF NORTH AMERICA AND THE AGE OF THE TRICERATOPS-BEDS; WITH REMARKS ON COMPARABLE DINOSAUR-BEARING BEDS OUTSIDE NORTH AMERICA (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 5. The Cretaceous-Tertiary Boundary, p. 25-40, 2 figs., 1960) 39 refs.

Triceratops-beds of the western interior of North America are of late Maestrichtian and not of Danian (=Montian) age. Generally accepted Cretaceous/Tertiary boundary in that region coincides, therefore, with Maestrichtian/Danian and not with Danian/Landenian boundary. All other alleged Danian dinosaur-bearing beds are demonstrably Maestrichtian or older. As far as we now know, dinosaurs had become extinct before the end of the Maestrichtian together with such typical Mesozoic groups of animals as ammonites, true belemnites (Belemnitellidae), Cretaceous planktonic Foraminifera, mosasaurs, pleisosaurs, ichthyosaurs, pterodactyls. Dinosaurs, therefore, also indicate the placing of Danian (=Montian) stage in the Cenozoic.--Auth.

3-2241. Spieker, Edmund M. THE CRETACEOUS-TERTIARY BOUNDARY IN UTAH (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 5. The Cretaceous-Tertiary Boundary, p. 14-24, 2 figs., 1960) 20 refs.

In central Utah the passage from Cretaceous to Tertiary, defined by the disappearance of the dinosaurs and the appearance of the early placental mammals, lies within the North Horn formation, an uninterrupted succession of fluviatile and lacustrine beds. Until recently the highest known dinosaurian remains and the lowest known mammalian have been separated by about 600 ft. of strata without diagnostic

fossils, a stratigraphic "no-man's-land." However, recent discovery of both mammalian and dinosaurian remains at new localities has narrowed down the gap, placing the boundary in the upper part of the hitherto unclassifiable interval.

The sequence of events accepted to determine this boundary is one of the most remarkable in geologic history. The disappearance of the dinosaurs has been ascribed to several possible causes, none thoroughly convincing, one of them the rising of mountains with attendant climatic change that supposedly invested the end of the Cretaceous. The evidence in Utah is totally against this idea. There the intense orogeny all occurred much earlier, and the dinosaurs became extinct at a time of regional quiet for which there is no evidence of important climatic change. The last dinosaurs must have been eliminated by other causes, possibly including epidemic disease.--Auth.

3-2242. Clemens, William A. STRATIGRAPHY OF THE TYPE LANCE FORMATION (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 5. The Cretaceous-Tertiary Boundary, p. 7-13, 1960) 10 refs.

In its type area in eastern Wyoming the dark, lenticular shales and lighter, cross-bedded sandstones of the Lance formation [Upper Cretaceous] are over 700 m. thick. These dinosaur-bearing sediments mark the initiation of continental deposition after the final retreat of the sea from this region. Correlations based on fossil invertebrates indicate that the underlying marine Fox Hills sandstone is of Maestrichtian age. Lying conformably on the Lance formation are well-bedded continental sandstones, shales, and lignites referred to the Fort Union formation [Eocene]. N. of the type area these sediments interdigitate with the marine Cannonball formation of Danian or younger age.

Many new types of small vertebrates have been added to the Lance fauna by application of special collecting techniques. The new collections of fossil mammals indicate that this element of the fauna is more diversified and abundant than is commonly believed. Because assemblages of fossil mammals of latest Cretaceous or earliest Tertiary age have not yet been found in western Europe the Lance mammals cannot be used to directly correlate this formation with the European standard. Currently available evidence warrants only a tentative correlation of the type Lance formation with the Maestrichtian and/or Danian age.--Auth.

3-2243. Hay, William W. THE CRETACEOUS-TERTIARY BOUNDARY IN THE TAMPICO EMBAYMENT, MEXICO (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 5. The Cretaceous-Tertiary Boundary, p. 70-77, 3 figs., 1960) 10 refs.

The series of green, gray, or red shales in the Tampico embayment has been subdivided into 2 formations, Mendez below and Velasco above, not distinguishable by lithology, color, or degree of induration, but solely through study of the microfaunal content. The upper part of the Mendez shale is characterized by Globotruncana contusa, Pseudotextularia varians, Planoglobulina acervulinoides, and Rugoglobigerina species, a late Maestrichtian fauna. The faunal change from Mendez to Velasco is profound, affecting both planktonic and benthonic Foraminifera. An angular unconformity separating Mendez and Velasco has been observed at a few localities, but the contact is usually paraconformable and generally invisible in the field. The Velasco formation is subdivided into 3 faunizones: 1) a basal Globigerina zone of Danian age with a lower Globigerinoides daubjergensis subzone and an upper Globorotalia uncinata subzone; 2) a middle zone characterized by Globorotalia pseudomenardii correlated with the Thanetian; 3) an upper zone with Globorotalia velascoensis of Sparnacian age. The middle and upper portions of the Velasco are undoubted Paleocene. Since the fauna of the Globigerina zone (Danian) is much more closely related to the Paleocene upper Velasco fauna than to the Cretaceous Mendez fauna, the Globigerina zone is assigned to the Paleocene also, and the Mendez-Velasco boundary coincides with the Cretaceous-Tertiary boundary.--Auth.

3-2244. Obregón de la Parra, Jorge. EL CONTACTO CRETACICO-TERCIARIO Y EL PALEOCENO DE LA CUENCA SEDIMENTARIA DE TAMPICO-MISANTLA [The Cretaceous-Tertiary Contact and the Paleocene of the Sedimentary Basin of Tampico-Misantla] (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 5. The Cretaceous-Tertiary Boundary, p. 78-81, 2 figs., 1960) 25 refs.; text in Spanish, abs. in English.

The Cretaceous-Tertiary boundary is discussed on the basis of foraminiferal assemblages and their equivalents in other regions, with evidence of stratigraphic data obtained in superficial geology.

The Globotruncana assemblage is characteristic of the upper Cretaceous and is followed by a nearly complete change in generic character and lithology in later beds.

The stratigraphic sequence of the Paleocene in the Tampico-Misantla embayment is correlated with others in Mexico, western Europe, the middle East, and North Africa.

An identical Globigerina assemblage occurs in the type Danian and in the base of the Velasco-Chicontepec group, followed by a Globorotalia-Truncorotalia assemblage, regarded as of Landenian age.--Auth.

3-2245. Murray, Grover E., and others. STRATIGRAPHY OF DIFUNTA GROUP, PARRAS BASIN, STATES OF COAHUILA AND NUEVO LEON, MEXICO (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 5. The Cretaceous-Tertiary Boundary, p. 82-96, 5 figs., table, 1960) 59 refs.

In the eastern part of the Parras basin, a forebasin immediately adjacent to and N. of the Sierra Madre Oriental in southern Coahuila and western Nuevo Leon, northeastern Mexico, the Late Cretaceous and Tertiary Difunta formation possesses a thickness in the order of 3,000 m. The Difunta, which overlies the Parras-Mendez shale of Austinian to Navarroan (approximately Coniacian-Santonian to Maestrichtian) ages, includes strata ranging from Austinian to Paleocene (Midwayan) in age.

Detailed stratigraphic measurements in the eastern part of the Parras basin disclose that in the Saltillo area, Coahuila, the Difunta consists of 2 gross lithic facies, which include 1) 4 gray to brown, calcareous, sand and shale units which intertongue to the S. and W. with 2) 3 red sand, shale, siltstone, and mudstone tongues, in part calcareous and fossiliferous. Conglomeratic beds are present from place to place in both facies but are most common in the lower red unit and the third (from base) gray-brown unit. The red beds thin or wedge out to the E. and N. of Saltillo.

The three red bed tongues possess a maximum, over-all, known thickness in the Saltillo area of approximately 1,300 m. The maximum known, over-all thickness of the gray-brown units in the same region is about 2,100 m.

Abundant fossils of Late Cretaceous are widely dispersed in the lower 3 units of the gray-brown facies. Sparse fossils of Paleocene (Midwayan) age have been found in the uppermost portion of the gray-brown facies.--Auth.

3-2246. Beckman, Jean Pierre. DISTRIBUTION OF BENTHONIC FORAMINIFERA AT THE CRETACEOUS-TERTIARY BOUNDARY OF TRINIDAD (WEST INDIES) (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 5. The Cretaceous-Tertiary Boundary, p. 57-69, 17 figs., 1960) 16 refs.

The most common and characteristic benthonic Foraminifera of the Upper Cretaceous Guayaguayare formation and the Danian-Paleocene lower Lizard Springs formation are briefly discussed. The faunas previously described by Cushman & Renz are revised. In addition, the benthonic Foraminifera from a number of yet undescribed samples have been examined. Most of these faunas contain also abundant planktonic Foraminifera.

Bolli has recently published descriptions of the planktonic species and has also established a detailed biostratigraphic subdivision of the Upper Cretaceous and lower Tertiary of Trinidad. It is therefore now possible to determine the stratigraphic ranges of most benthonic Foraminifera with great accuracy and to prove that several of the faunas described by Cushman & Renz are heterogeneous.

It is clearly shown that whereas the major change in the planktonic faunas occurs at the top of the Maestrichtian, the benthonic fauna of the Upper Cretaceous continues into the lowermost Tertiary, up to the zone with Globorotalia velascoensis. This was the main reason why Cushman & Renz, who put the emphasis on the benthonic Foraminifera, gave an Upper Cretaceous age to the Lizard Springs formation.--Auth.

3-2247. Rainwater, Edward H. PALEOCENE OF THE GULF COASTAL PLAIN OF THE UNITED STATES OF AMERICA (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 5. The Cretaceous-Tertiary Boundary, p. 97-116, 6 figs., 1960) 119 refs.

Strata of Paleocene age are well exposed in a narrow belt extending from Mexico E. to the Chattahoochee River, a distance of about 1,500 mi. In addition, strata of that age are known, from many wells drilled for oil and gas, to extend far gulfward in the subsurface. The volume of Paleocene sediments in this area probably exceeds 50,000 cu. mi.

Throughout most of the Gulf Coast, the uppermost Cretaceous and lowermost Paleocene are both marine, and the boundary between the 2 can usually be determined in outcrop and in well sections by the sharp change in macrofaunas and microfaunas. The top of the Paleocene has not been determined precisely in most outcrop and well sections.

It appears that the Upper Cretaceous sea over North America was greatly restricted during Paleocene time, but that in the Gulf Coast the sea was shallowed to permit wave and ocean-current erosion (but not subaerial erosion) of the Cretaceous surface. Later in the Paleocene, regressive, nonmarine conditions dominated in the area.

The depositional history of this period is explained and illustrated by maps and cross sections. It is recommended that the outcrop section in southwestern Alabama be considered a possible type section of Paleocene.--Auth.

3-2248. Taylor, F.C. INTERGLACIAL(?) CONGLOMERATE IN NORTHERN MANITOBA, CANADA: Geol. Soc. America, Bull., v. 72, no. 1, p. 167-168, Jan. 1961, 7 refs.

A conglomerate of probable interglacial origin was discovered in 1957 in the valley of the Seal River at 58°58'N. 96°38'W. Many such deposits are known in the western provinces; however, none have been reported in the N. latitudes. The conglomerate contains a flora similar to that of the present day in the area. Degree of alteration suggests an interglacial rather than postglacial origin for the conglomerate.--B. W. Pipkin.

3-2249. Hopkins, D. M., and others. THE COASTAL PLAIN AT NOME, ALASKA: A LATE CENOZOIC TYPE SECTION FOR THE BERING STRAIT REGION (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 4. Chronology and Climatology of the Quaternary, p. 46-57, 4 figs., 1960) 8 refs.

The richly fossiliferous sequence of marine and nonmarine sediments on the coastal plain at Nome contains a nearly complete record of Quaternary sea-level fluctuations and climatic events. Mining excavations reveal 3 marine stratigraphic units recording 3 distinct intervals during which sea level stood as high as or higher than at present and during which sea temperatures were warmer than at present. The oldest unit is of late Pliocene or early Pleistocene age; the 2 younger units are of middle and late Pleistocene age. Glacial drift separates the marine units from one another and colluvium and peat that accumulated during the last 13,000 years cover the glacial drift and the youngest of the marine sediments.

Study of the pollen and microstratigraphy of the colluvium and peat yields a continuous record of vegetational and climatic changes at Nome during late Pleistocene and Recent time. A severe arctic climate about 11,000 B. C. was followed by an interval when summers were warmer than at present, 8,000 to 6,000 B. C., then by an interval encompassing the last 8,000 years when the climate and vegetation differed little from present conditions at Nome.--Auth.

3-2250. Rankin, Douglas W. PALEOGEOGRAPHIC IMPLICATIONS OF DEPOSITS OF HOT ASH FLOWS (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 12. Regional Paleogeography, p. 19-34, 2 figs., 3 tables, 1960) 66 refs.

A thick felsitic welded tuff of Early Devonian age, believed to have been deposited by hot ash flows, crops out over 90 sq. mi. in the vicinity of Traveler Mountain, N.-central Maine. These welded tuffs were probably deposited in a regional marine environment.

Pyroclastic sheets believed to have been deposited by hot ash flows (nuées ardentes) lack all but the crudest internal stratification, consist primarily of poorly sorted pumice fragments and/or shards or their devitrified equivalents, and contain evidence

of high temperature at the time of deposition. Syngenetic high temperature may be indicated by any of the following features: 1) welded tuff, 2) columnar jointing, 3) charred organic material.

Hot ash flows, because of their low specific gravity (less than 1.0), could not form subaqueously. Therefore, hot ash flow deposits require a subaerial environment of deposition.

Hot ash flow deposits described in the literature almost invariably had terrestrial environments of deposition. The 3 known exceptions that occurred in marine environments, are not inconsistent with temporary nonmarine conditions.

The presence of a hot ash flow deposit, therefore, implies at least a temporary subaerial environment. This conclusion may be used in solving paleogeographic and related problems when other evidence is lacking or inconclusive.--Auth.

3-2251. Kay, Marshall. PALEOZOIC CONTINENTAL MARGIN IN CENTRAL NEVADA, WESTERN UNITED STATES (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 12. Regional Paleogeography, p. 94-103, 4 figs., 1960) 34 refs.

The original relations between the Paleozoic miogeosynclinal and eugeosynclinal belts in western North America have been confused by the complex structural history that affected the rocks. In western Utah and eastern Nevada, the Paleozoic systems are dominated by carbonate rocks, with thick basal orthoquartzite and several quartzite units of eastern source. Only the eastern margin of the eugeosynclinal belt exposes the earlier Paleozoic systems, in a belt extending through central Nevada from Idaho to California; the rocks are siliceous argillite and graywacke, some with graptolites, and radiolarian cherts, with associated rocks as varied as pillow lavas, boulder-bearing mudstones and quite pure orthoquartzites. Sequences in the miogeosynclinal belt are generally quite constant, reflecting rather regular subsidence. The eugeosynclinal sequences are more varied in thicknesses and lithologies, their terrigenous detritus coming principally from welts to the W., but occasionally from the rather stable shelf on the E. Relations between belts can be reconstructed in limited areas where the transitional rocks are preserved in a succession of thrust slices, as in the Toquima Range. The transition zone was one of varied character. Some systems grade through intertonguing argillites on the W. and carbonates on the E.; in other systems and places, the continuity is interrupted by unconformity through nondeposition or postdepositional erosion. Folding and thrust faulting affected the eastern margin of the eugeosynclinal belt strongly in Carboniferous and Permian, the welts producing coarse detritus that invaded the miogeosynclinal belt.--Auth.

3-2252. Kulp, J. Laurence. THE GEOLOGICAL TIME SCALE (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 3. Pre-Quaternary Absolute Age Determination, p. 18-27, 2 figs., 2 tables, 1960) 24 refs.

New isotopic age determinations on rocks with reasonably well defined stratigraphic position permit a refinement of the time scale from the Cambrian to the Recent. The entire history of the earth may be placed on a more quantitative basis. The key points in the scale are discussed in some detail from new isotopic measurements using the K-Ar, Rb-Sr, and U(Th)-Pb methods obtained at this laboratory and elsewhere. Some of these include Wichita Mts., Oklahoma (Cambrian), Nova Scotia and English granites (Devonian), Vosges and French Central Massif granites (lower Carboniferous), SW. England granites (top Carboniferous), Palisades New Jersey sill (Upper Triassic), Sierra Nevada and Coast Range granites (Jurassic and Cretaceous), and various Tertiary extrusives. The problem of the age of the Swedish kolm is also discussed. Precambrian age measurements are evaluated in terms of major orogenic cycles and the concepts of continental growth and worldwide synchroneity of the larger scale events. These considerations lead to a revised geological time scale.--Auth.

3-2253. Folinsbee, R. E., and others. POTASSIUM-ARGON TIME SCALE (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 3. Pre-Quaternary Absolute Age Determination, p. 7-17, 4 figs., table, 1960) 34 refs.

At certain key points on the paleontologic time scale it has been possible to collect minerals of known biostratigraphic age amenable to K-Ar dating. [Most of the minerals dated are from Canada.]

Late Cretaceous (Maestrichtian) sanidines from a dinosaur-bearing bentonite bed give an age of 66 m.y., mica from the same horizon ages of 75 and 79 m.y. Upper Cretaceous (Campanian) volcanic bentonites give biotite ages of 68 and 82 m. y. A mid-Cretaceous sanidine is 94 m. y. old, but middle Albian biotite is 114 to 119 m. y. old. This suggests Ar leakage from sanidine. K-Ar ages for Cretaceous and Jurassic glauconites are variable, usually younger than correlative biotite or sanidine ages.

Sanidine from an Exshaw shale bentonite which marks the Devonian-Mississippian contact gives ages of 242 and 250 m. y., figures in agreement with Holmes time scale. A well ordered lower Cambrian glauconite gives ages of only 395-413 m. y.; it has almost certainly lost radiogenic Ar.

Though there now exists a considerable body of evidence on the age of minerals from known points of post-Precambrian time, our data will not allow any major revision of the Holmes scale.--Auth.

3-2254. Smith, D. G. W., and others. K/Ar AGE OF LOWER DEVONIAN BENTONITES OF GASPÉ, QUEBEC, CANADA: Geol. Soc. America, Bull., v. 72, no. 1, p. 171-173, map, table, Jan. 1961, 11 refs.

The Devonian Grande Grève formation (900 ft.) of the Gaspé limestone sequence is at the top of the lower Coblenzian substage (Oriskany). Six bentonite beds, ranging in thickness from a few inches to more than a foot, lie in the lowermost 100 ft. of the formation. Sanidine and biotite in the bentonites are a reliable cogenetic pair for the purposes of K/Ar age determinations. The ages so determined are in agreement with the minimum age of the Lower Devonian obtained by other workers. The suggested age of 385 ± 15 m. y. is in accord with the revised time scale of Holmes and compares favorably with a number of dates obtained for intrusions in Lower Devonian sediments in New England and Acadia.--B. W. Pipkin.

3-2255. Toulmin, Priestley, 3d. GEOLOGICAL SIGNIFICANCE OF LEAD-ALPHA AND ISOTOPIC AGE DETERMINATIONS OF "ALKALIC" ROCKS OF NEW ENGLAND: Geol. Soc. America, Bull., v. 72,

no. 5, p. 775-779, fig., 2 tables, May 1961, 28 refs.

Recent age determinations indicate that at least 2 groups of "alkalic" igneous rocks exist in New England, with ages of about 185 and 270 million years. Because of their lithologic and geologic similarities, all these rocks had previously been grouped with the White Mountains plutonic-volcanic series of New Hampshire. Until reliable petrographic or geologic criteria become available for distinguishing these age groups, caution should be exercised in assigning any undated body of "alkalic" rock to one or the other group.--Auth.

3-2256. Baadsgaard, H., and others. POTASSIUM-ARGON DATES OF BIOTITES FROM CORDILLERAN GRANITES: Geol. Soc. America, Bull., v. 72, no. 5, p. 689-701, 4 figs., table, May 1961, 60 refs.

Biotites from 20 plutons of the Cordillera of North America, principally from British Columbia, have been dated using the K-Ar method. Samples were selected from well-known intrusive masses in an attempt to compare physically measured dates with relative age established by geological mapping; most dates confirm the geological age interpretations.

The Cordillera underwent granitic intrusion or orogeny at 5 times separated by long periods of quiescence. The earliest orogeny, of Devonian (Acadian) age, occurred 350-360 million years ago and resulted in intrusion of plutons as widely separated as the Ice River syenite of the Rocky Mountains and the Fitton granite of the northern Yukon.

Early Mesozoic orogeny resulted in the emplacement of the upper Triassic or lower Jurassic Guichon (186 m.y.) and Topley (163 m.y.) batholiths of central British Columbia. The major Cordilleran intrusion occurred 95-100 million years ago, in about the middle of the Cretaceous, with emplacement of the Coast Range batholith and early phases of the Nelson batholith of British Columbia, and the Cassiar and Itsi batholiths of Yukon. In late Cretaceous time, 80 million years ago, the Bayonne pluton, British Columbia, and Boulder batholith and Marysville stock of Montana were emplaced.

During Rocky Mountain orogeny (Eocene), 50-60 million years ago, late phases of the Nelson batholith and a number of plutons such as Coryell were emplaced. Eighteen million years ago, in the Miocene, small granitic bodies intruded the Cascade Range; these are believed to be the youngest exposed batholitic rocks in North America.--Auth.

3-2257. Clark, David L. U-Pb AGE DETERMINATION AND UPPER DEVONIAN BIOSTRATIGRAPHY: Geol. Soc. America, Bull., v. 72, no. 1, p. 163-165, Jan. 1961, 10 refs.

Recently, Cobb and Kulp published data concerning the U-Pb age determinations of the Upper Devonian Chattanooga shale from Tennessee. The authors concluded that an absolute age of 350 m.y. for the Gassaway member of the Chattanooga shale would appear to establish a firm minimum age for the Devonian-Mississippian boundary. Biostratigraphic evidence indicated that the Gassaway member is separated from the overlying Kinderhookian Maury formation by an unconformity and is not "uppermost Devonian." The precise stratigraphic position of the unit can be determined by comparison with the standard conodont zonation based upon the European type; when correlated, however, the Gassaway member proves to be upper-lower-Upper Devonian or lower-middle-Upper Devonian. This would indicate a significant time gap between the age of the black shale and the Devonian-Mississippian boundary. The figure of 350 m.y. of Cobb and Kulp is in reality not a minimum, but a maximum age for the boundary, and the true age is probably 10-15 m.y. less than this. Since 10-15 m.y. is within the range of experimental error, this fact does not radically change the significance of the date but simply emphasizes the importance of biostratigraphic understanding in the application of geochemical dates to the stratigraphic section.--B. W. Pipkin.

3-2258. Hurley, Patrick M., and others. GEOCHRONOLOGY OF PROTEROZOIC GRANITES IN NORTHERN TERRITORY, AUSTRALIA. PART 1: K-Ar AND Rb-Sr AGE DETERMINATIONS: Geol. Soc. America, Bull., v. 72, no. 5, p. 653-662, map, 3 tables, May 1961, 8 refs.

K-Ar and Rb-Sr age measurements on granitic rocks intrusive into 2 subdivisions of the lower Proterozoic in the Northern Territory of Australia show well-grouped ages averaging 1,440 and 1,630 million years. The writers present reasons for their belief that these are close to the true values for the times marking the end of 2 disturbances which produced intracratonic basins of sedimentation.--Auth.

3-2259. Walpole, B. P., and K. G. Smith. GEOCHRONOLOGY OF PROTEROZOIC GRANITES IN NORTHERN TERRITORY, AUSTRALIA. PART 2: STRATIGRAPHY AND STRUCTURE: Geol. Soc. America, Bull., v. 72, no. 5, p. 663-668, table, May 1961, 4 refs.

K-Ar and Rb-Sr dating of 24 Proterozoic granites from the Northern Territory of Australia shows 2 main groups of ages averaging 1,630 and 1,440 million years. Both groups of granite were emplaced at the end of a period of folding. The regional structure connects the first period of folding with the lower, and the second with the upper, subdivision of what is regarded as lower Proterozoic. The older group of granites (1,630 million years) marks the top of the lower subdivision, and the younger group marks the top of the lower Proterozoic. The base of the Proterozoic would naturally be much older than 1,630 million years.

Major deviations from the average ages quoted are possibly due to recrystallization of mica or diffusion loss of Ar resulting from local deformation or deeper burial of the rocks at the sample localities. --Auth.

3-2260. Swann, David H., and H. B. Willman. MEGAGROUPS IN ILLINOIS: Am. Assoc. Petroleum Geologists, Bull., v. 45, no. 4, p. 471-483, 2 figs., Apr. 1961, 29 refs.

The term "megagroup" is proposed as a formal designation for a rock-stratigraphic unit larger than group. Although comparable in size with series and systems, megagroups are defined in terms of lithology and transect the boundaries of units that are based on time of deposition.

Seven megagroups are herein recognized in the pre-Pennsylvanian and one in the Mesozoic and Cenozoic rocks of the Illinois region. The Potsdam sandstone megagroup includes the formations in the basal sandstone succession of Cambrian and earliest Ordovician age. The Knox dolomite megagroup of

Cambrian and Ordovician age is in part contemporaneous with the Potsdam and extends from the base of the St. Peter sandstone down only to the base of the Potosi dolomite in northern Illinois but to the base of the Bonneterre dolomite in southwestern Illinois. The Ottawa limestone megagroup is the Middle and Upper Ordovician carbonate sequence above the St. Peter, Glenwood, Aylmer, or Simpson clastics. The Maquoketa shale of Upper Ordovician age does not require megagroup treatment within Illinois, though a megagroup might be useful farther E. where such clastics include Middle and Upper Ordovician and Lower and Middle Silurian rocks. The Hunton limestone megagroup is the major Silurian-Devonian carbonate succession. Knobs megagroup is proposed for the Devonian-Mississippian clastic wedge marking the Acadian orogeny. The Mammoth Cave limestone megagroup is a formal substitute for the "Mississippi lime" of common usage. The Pope megagroup is proposed for the sequence of alternating clastic and limestone deposits of Mississippian age above the Mammoth Cave megagroup. A formal megagroup name appears unnecessary for the dominantly clastic Pennsylvanian rocks of the Illinois region. The Embayment megagroup is proposed for the unconsolidated clastics of Cretaceous and Tertiary age of extreme southern Illinois. --Auth.

3-2261. Zeller, Edward J., and others. BASAL SEDIMENTARY SECTION AT WINDY GULLY, TAYLOR GLACIER, VICTORIA LAND, ANTARCTICA: Geol. Soc. America, Bull., v. 72, no. 5, p. 781-785, 5 illus., 2 maps, sec., table, May 1961, 10 refs.

The contact between the basement complex and the sedimentary sequence in the Royal Society Range is well exposed on both sides of Windy Gully along the main valley of the Taylor Glacier. The basal beds, consisting of cross-bedded sandstones, are overlain by 110 ft. of alternating sandstones and dark fissile shales. Overlying these beds are massive sandstones of "normal" Beacon lithology. A 960-ft. diabase sill has been injected 255 ft. above the base of the massive sandstone unit. The section was measured for 390 ft. above the top of the sill and probably overlaps with the lower portion of the Beacon section recently described by McKelvey and Webb.--Auth.

5. PALEONTOLOGY

See also: Geomorphology 3-2171; Stratigraphy 3-2215, 3-2221, 3-2233, 3-2238 through 3-2244, 3-2246.

3-2262. Glaessner, Martin F. PRE-CAMBRIAN ANIMALS: Sci. American, v. 204, no. 3, p. 72-78, illus., 2 maps, sec., March 1961.

The lack of suitable fossils from the Precambrian has long puzzled paleontologists. Now the discovery of a whole fauna in the Ediacara Hills of South Australia has reopened the investigation of the "age of jellyfish." These fossils include 2 forms of probable sea-pens (alcyonarian corals), 6 genera of small jellyfish, segmented worms with head shields, and flat, bilaterally symmetrical, elliptical worms, as well as 2 creatures unlike any form known today. The fauna, of some 600 specimens, appears to have been stranded and preserved on a back beach and is found in irregular sericitic partings in quartzite of undoubted Precambrian age. Five hundred ft. higher in the column occur fossils of the Lower Cambrian with none of these same forms, in spite of similarity of rock types. Mention is made of isolated finds of sea-penlike Precambrian forms in SW. Africa and England.--R. F. McAllister.

3-2263. Mellersh, H.E.L. THE STORY OF EARLY MAN; HUMAN EVOLUTION TO THE END OF THE STONE AGE: 257 p., illus., maps, New York, Viking Press, 1960, 43 refs.

This book draws primarily from archeology and anthropology to relate, in lay terminology, the story of human evolution to the end of the Stone Age, but historical geology and general paleontology are extensively presented to establish many of the primary concepts. First is traced man's inheritance, of body, of brain and sensitivity, and of environment. Then is told the story of the long transition from food gathering to hunting and agriculture, the birth of language, the flowering of art, the natural bases of magical practices, the growth of religious beliefs, the spread of crafts, the gathering of populations into villages which grew into cities, and the push from fertile valleys of the Near East to populate Europe and Asia. The book ends when neither man nor his mind seem any longer properly describable as primitive or prehistoric, when the Stone Ages are past and the scent of civilization is in the air.--From introd.

3-2264. St. Jean, Joseph, Jr. THE WIDESPREAD DISTRIBUTION OF CHARACTERISTIC DEVONIAN STROMATOPOROID MICROSTRUCTURES AND THEIR STRATIGRAPHIC SIGNIFICANCE (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 21. Other Subjects, p. 239-250, 3 figs., 1960) 11 refs.

In connection with studies of Middle Devonian stromatoporoid faunas from the midwestern United States and the province of Ontario, Canada, it has been found that easily recognizable minute details of stromatoporoid morphology occur in geographically widespread species. Therefore, such structures may be of stratigraphic value. Geographic persistence of stromatoporoid microstructure further suggests that minor micromorphology represents genetically induced factors, partially or completely independent of environmental control, which enhances the stratigraphic usefulness of stromatoporoids and is of phylogenetic importance.

Some examples of the more widespread minute morphological characteristics in stromatoporoids are: the arrangement of the maculae in the laminar and pillar tissue of Parallelpora, Stromatopora, and Syringostroma; the straight transverse and anastomosing tubulose structures in the laminar and pillar tissue of Stromatoporella; a reticulate microtissue in some species of Stromatoporella; finely striated horizontal lineations in the pillars of Anostylostroma and Actinostroma; abnormally thick perithecal structures in Stictostroma and Stromatoporella; and the presence of dark microlaminae in several species of Stromatopora. The above-mentioned structures are noted in Devonian stromatoporoids from northern Europe, the Kuznetsk basin in the Soviet Union, and central North America.--Auth.

3-2265. Pierce, W. Dwight. SILICIFIED TURBELLARIA FROM CALICO MOUNTAINS NODULES:

Southern California Acad. Sci., Bull., v. 59, pt. 3, p. 138-143, 2 pls., table, Sept.-Dec. 1960.

The material discussed constitutes the first fossil record of the class Turbellaria. Silicified specimens were extracted by formic acid from calcareous petroliferous nodules of Miocene age recovered from lake-bed deposits in the Calico Mountains, San Bernardino County, California. The nodules were found in 6 quarter sections at 10 sites, from altitudes of 2,500 to 2,800 ft. The material includes 1 Rhabdocoela, 1 Rhynchodemidae and 4 Planariidae [Tricladida]; as well as 2 types of eggs believed to be turbellarian, the first type in 2 nodules, in strips totalling 360 eggs, the second type in 8 nodules, totalling 53 eggs.--Auth.

3-2266. Boardman, Richard S. A REVISION OF THE ORDOVICIAN BRYOZOAN GENERA BATOSTOMA, ANAPHRAGMA, AND AMPLEXOPORA: Smithsonian Inst., Smithsonian Misc. Colln., v. 140, no. 5, p. 1-28, 7 pls., 6 tables, Dec. 1960, 26 refs.

Restudy of the primary types of the family Amplexoporidae in the U. S. National Museum collection has resulted in the reassignment of about half the species previously placed in Batostoma to Amplexopora, giving a picture of morphologic trends and hypothesized lineages which suggests that species of Amplexopora will prove extremely useful in stratigraphic paleontology.

The genus Stromatotrypa Ulrich, 1893, was investigated in connection with Batostoma, and study of new sections of the type species, S. ovata Ulrich, 1893, resulted in Stromatotrypa being considered a junior subjective synonym of Batostoma.

The genus Acanthotrypella Vinassa de Regny, 1920, was considered to be a junior subjective synonym of Batostoma by Bassler. Study of new sections of the type species, B. variabile Ulrich, 1890, resulted in Acanthotrypella being considered a junior subjective synonym of Amplexopora. Systematic descriptions are given of Batostoma, Anaphragma, and Amplexopora.--From auth. introd.

3-2267. Norford, B. S. A WELL-PRESERVED DINOBOLUS FROM THE SANDPILE GROUP (MIDDLE SILURIAN) OF NORTHERN BRITISH COLUMBIA: Palaeontology, v. 3, pt. 2, p. 242-244, pl., Aug. 1960, 5 refs.

A silicified individual allows a more detailed description of the posterior portion of Dinobolus than was previously available. There is no trace of the existence of a pedicle, and a functional pedicle may have been atrophied in the genus.--Auth.

3-2268. Boucot, Arthur J. IMPLICATIONS OF RHENISH LOWER DEVONIAN BRACHIOPODS FROM NOVA SCOTIA (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 12. Regional Paleogeography, p. 129-137, 3 figs., 1960) 23 refs.

A Lower Devonian brachiopod fauna from Nova Scotia having Rhenish rather than Appalachian affinities sheds new light on Lower Devonian zoogeography. The fauna contains Rhenish brachiopods and trilobites but lacks elements that characterize equivalent Appalachian faunas.

The Nova Scotia fauna occurs at 45° N. Appalachian Lower Devonian faunas to the N. and to the SW. are sharply separated from the Rhenish Nova Scotia fauna as are the Lower Devonian faunas of Czechoslovakia, the Carnic Alps, and North Africa relative to the Rhenish faunas of Devon, Brittany, the Ardennes, and the Schiefergebirge. The geographic position of the Nova Scotia fauna implies that in eastern North America 45° N. formed the southern limit of a North Atlantic Rhenish province in Lower Devonian time.

The occurrence of Rhenish Lower Devonian brachiopods and trilobites in the Malvinokaffric province of the South Atlantic suggests that it and the North Atlantic Rhenish province exchanged certain elements by submergence (in the sense of Ekman). The northern limits of the Malvinokaffric province are near the Equator (Lake Titicaca in Bolivia, possibly Accra in Ghana).

The Middle Devonian Hamilton fauna of the Appalachians contains Lower Devonian Rhenish elements that are absent in subjacent Lower Devonian Appalachian faunas. This important faunal change coincides with the marked changes in land-sea relationships initiated by the Acadian (=Middle Devonian phase of the Caledonian) orogeny, which locally may have upset current regimes sufficiently to allow elements of the North Atlantic Rhenish fauna to penetrate southward into a formerly unfavorable environment. These latitudinal relationships suggest that the North Atlantic Rhenish fauna was restricted to northern waters and that the Acadian orogeny disturbed shallow-water current regimes so that northern waters penetrated farther S.

Known distribution of Silurian and lower Gedinnian brachiopods in the Northern Hemisphere suggests that relatively uniform conditions prevailed during those times. The existence of many distinct faunal provinces in Siegenian to Eifelian time, in contrast to the relatively cosmopolitan Silurian to lower Gedinnian and Givetian to Famennian faunas, coincides roughly in time with the marked changes in land-sea relationships during the Middle Devonian phase of the Caledonian orogeny, which may have produced a greater variety of shallow-water marine habitats than existed during Silurian to lower Gedinnian and Givetian to Famennian times in the North Atlantic region.--Auth.

3-2269. Pedder, A. E. H. NEW SPECIES OF BRACHIOPODS FROM THE UPPER DEVONIAN OF HAY RIVER, WESTERN CANADA: Palaeontology, v. 3, pt. 2, p. 208-216, fig., 2 pls., Aug. 1960, 14 refs.

Nervostrophia borealis, N. maclareni, and Cyrtina lapidea are described and figured as new species from the Hay River formation of the Northwest Territories. Douvillinella? crickmayi is described and figured as a new species from the lower Grumbler formation of the same area. All the fossils are of Frasnian age.--Auth.

3-2270. La Rocque, J. A. Aurèle. QUANTITATIVE METHODS IN THE STUDY OF NON-MARINE PLEISTOCENE MOLLUSCA (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 4. Chronology and Climatology of the Quaternary, p. 134-141, fig., 5 tables, 1960) 17 refs.

Successive populations of Mollusca accumulated in Pleistocene lake deposits record fluctuations due in part to climate changes but affected also by changes in pH of water, water depth, bottom conditions, influx from streams, floods, ice action, and vegetation. Studies on 6 Pleistocene lakes in Ohio reveal wide variation in composition of molluscan faunas in all 6 lakes and in successive 2-in. beds within 1 deposit. Such variations can be accounted for on the basis of

limnologic and ecologic data for the same species now living in the same region or elsewhere. Two concepts of interest emerge from these studies.

First, the bearing of paleoecology on index fossils for the divisions of the Pleistocene is of cardinal importance. Index fossils useful in one area have a materially different meaning in another because of position of the areas with respect to foci of migration and nature of the environment available for migrating Mollusca.

Secondly, minute changes in the molluscan faunas can be used to reconstruct the detailed history of a deposit. Given a sufficient number of local histories, the Pleistocene history of an area can be reconstructed, within the limits of the information yielded by molluscan populations.--Auth.

3-2271. Young, Keith. LATER CRETACEOUS AMMONITE SUCCESSIONS OF THE GULF COAST OF THE UNITED STATES (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 21. Other Subjects, p. 251-260, chart, 1960) 28 refs.

The later Cretaceous rocks of the Gulf Coast of the United States contain a distinct succession of ammonites, some of which previously have not been reported. The Coniacian contains a lower zone of Peroniceras, n. sp., and an upper zone of Peroniceras westphalicum (Schlüter). The Santonian is represented by 4 zones, which, in ascending order, are the zones of Texanites stangeri densicostus (Spath), T. texanus texanus (Römer), T. texanus gallicus Collignon, and Bevahites sp. cf. B. bevahensis Collignon.

Above the Santonian the Campanian is represented by the zones of Submortoniceras sp. aff. S. tenuicostulatum Collignon, Delawarella delawarensis (Morton), Delawarella sp. aff. D. roedereri Collignon, Hoplitoplacenticeras marroti (Coquand), and Bostrychoceras sp. aff. B. polyplocum (Römer). The zone above the B. sp. aff. B. polyplocum zone contains many species of Nostoceras and Axonoceras, and also contains Menuites, n. sp., Mnambolites, n. sp., and 2 species of Placenticeras; presumably this zone is Campanian also, but its relationship to overlying and underlying zones is not clear.

In Mexico the Maastrichtian has the 5 zones, which, in ascending order, are Coahuilites sheltoni Böse, Sphenodiscus lenticularis (Owen), S. intermedius Böse, C. cavinsi Böse, and S. pleuriseptus (Conrad). To the N. the lower zones (zones of C. sheltoni to zone of S. intermedius inclusive) are cut out or are replaced by a Nostoceras fauna.--Auth.

3-2272. Zangerl, Rainer. THE VERTEBRATE FAUNA OF THE SELMA FORMATION OF ALABAMA. PART V. AN ADVANCED CHELONIID SEA TURTLE: Chicago, Nat. History Mus., Fieldiana: Geology Mem., v. 3, no. 5, p. 281-312, 21 figs., 4 pls., Aug. 1960, 28 refs.

A new cheloniid sea turtle [Corsochelys haliniches] is described from the Mooreville chalk (late Cretaceous) of Alabama. Only a single specimen is presently known, and this is probably not a fully mature individual, in spite of its large size. In many respects this turtle is greatly advanced in the direction of marine specialization, as is true of most Cretaceous cheloniids. In the differentiation of its locomotor apparatus, however, it appears to be as primitive as is Desmatochelys.

The present state of knowledge of the Cretaceous cheloniid sea turtles is very unsatisfactory, and a review based on reexamination of virtually all of the material is clearly indicated.--Auth. summ.

3-2273. Etheridge, Richard. THE PLIOCENE LIZARD GENUS EUMECOIDES TAYLOR: Southern California Acad. Sci., Bull., v. 59, pt. 2, p. 62-69, May-Aug. 1960, 8 refs.

Comparisons of the type specimens of Eumecoides mylocoelus and Eumecoides hibbardi from the Rexroad fauna (upper Pliocene) of Meade County, Kansas, with about 200 fossil horned lizards of the genus Phrynosoma from the same beds indicates that Eumecoides is a synonym of Phrynosoma. Comparisons of Rexroad Phrynosoma with modern skeletons of Phrynosoma cornutum indicate that the Rexroad fauna contained only one species of horned lizard and that this was very similar to modern Phrynosoma cornutum. Eumecoides hibbardi and Eumecoides mylocoelus are thus considered conspecific with Phrynosoma corutum. --Auth.

3-2274. Langston, Wann, Jr. THE VERTEBRATE FAUNA OF THE SELMA FORMATION OF ALABAMA. PART VI. THE DINOSAURS: Chicago, Nat. History Mus., Fieldiana: Geology Mem., v. 3, no. 6, p. 315-361, 18 figs., pl., Aug. 1960, 25 refs.

Poorly preserved remains of 3 dinosaurs have recently been recovered from marine Upper Cretaceous, presumably early Campanian, rocks SE. of Marion Junction, Dallas County, Alabama. The collection contains a partial skeleton of a new genus and species of hadrosaur, Lophorhothon atopus, an ilium of a nodosaurid, and a proximal pedal phalanx of a small carnosaur. The hadrosaur skeleton had evidently floated a mile or so seaward as a partly dried cadaver before it sank in relatively quiet water, where it was buried in partial articulation by sediments of the Mooreville chalk member of the Selma formation. The nodosaurid and carnosaur bones presumably fell away from similarly floating carcasses.

These dinosaurs are among the oldest Upper Cretaceous dinosaurs from North America. They can be compared satisfactorily only with various forms from western North America.

The type specimen of Lophorhothon atopus was a very young individual whose cranial sutures were not completely closed, whose fronto-nasal fontanel was large, and whose replacement bones were not completely formed. The living animal was perhaps 15 ft. long, but adult individuals were probably among the largest of hadrosaurs. The hadrosaurine affinities of Lophorhothon are revealed by the hoodless cranium, the slender nonexpanded ischium, and the angle between root and crown in dentary teeth. General skull shape and presence of a nasal crest suggest relationships to Kritosaurus and Prosaurolophus, but similiarities to Kritosaurus are more extensive and more basic in the skeleton as a whole. Geologically Lophorhothon was antecedent to both, but phylogenetically it was more closely (though not ancestrally) allied to Kritosaurus, which, however, possessed a more primitive nasal crest.

Ribs in the tail of the type of Lophorhothon atopus are not fused with their vertebrae, showing that the caudal transverse processes of authors are true caudal ribs in hadrosaurs.

The type specimen of Lophorhothon atopus was so preserved that some details of cranial anatomy hitherto unobserved in hadrosaurs are clearly shown. Examination of other material in light of these ob-

servations makes possible certain conclusions that are probably applicable to hadrosaurs generally.--From auth. summ.

3-2275. Miller, Loye. NOTES ON THE PLEISTOCENE FLIGHTLESS GOOSE, CHENDYTES: Southern California Acad. Sci., Bull., v. 59, pt. 2, p. 57-61, pl., table, May-Aug. 1960, 5 refs.

This reports on additional fragmentary finds of the Pleistocene flightless goose, Chendytes, from San Nicolas Island in the San Diego area, California. Leg and toe elements, in a strongly flexed position, indicate that one adaptation to the flightless condition was stronger legs and more erect stature in walking. --M. Russell.

3-2276. Reeder, William G. A NEW RODENT GENUS (FAMILY HETEROMYIDAE) FROM THE TICK CANYON FORMATION OF CALIFORNIA: Southern California Acad. Sci., Bull., v. 59, pt. 3, p. 121-132, 3 pls., table, Sept.-Dec. 1960, 9 refs.

The heteromyid Trogomys rupinimenthae n. gen., n. sp., from the late Arikareean or early Hemingfordian, Miocene, Tick Canyon formation of California is described. This and related genera Perognathus and Mookomys may form the subfamily Perognathinae.--M. Russell.

3-2277. Skilling, G.F. MICROFOSSIL RESEARCH: Can. Oil & Gas Industries, v. 13, no. 10, p. 39-40, table, Oct. 1960.

Research in micropaleontology is being carried on in only 8 of 17 Canadian universities, in the provinces of British Columbia, Alberta, Saskatchewan, Ontario, and New Brunswick. Work in progress covers almost every geologic system except the Triassic, dealing with Foraminifera, conodonts, megaspores, and stromatoporoid corals. Oil and gas companies and professional societies realize more research is needed, and specific projects should be encouraged.--C.G. Winder.

3-2278. Gutschick, Raymond C. EARLY MISSISSIPPIAN (LOWER CARBONIFEROUS-TOURNAISIAN) MICROPALEONTOLOGY IN THE UNITED STATES (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 6. Pre-Quaternary Micropaleontology, p. 114-134, 2 figs., 1960) 109 refs.

This paper reviews the status of micropaleontology of Kinderhookian and Osagian rocks in the United States. Early Mississippian microfaunas are widespread and diverse and include: conodonts, Foraminifera-arenaceous and calcareous, ostracodes, echinoderm material-microcrinoids, holothurian sclerites, echinoid plates, starfish ossicles, and abundant crinoid debris, sponge spicules, scolecodonts, radiolarians, calcareous algae including charophytes, spores and miscellaneous embryonic, diminutive, and problematic forms.

Stratigraphic distribution is shown as indicated by the numerous conodont studies which have concentrated on the Devonian-Mississippian boundary problem. The arenaceous Foraminifera represented by astrorhizids, saccamminids, hyperamminids, reophacids, tolypamminids, and lituolids in the silty, argillaceous limestones of the Rockford-Chouteau equivalents in the Midwest, the Welden-Chappel rocks of the Midcontinent region and the Madison-Lodgepole limestone of the Rocky Mountains will be useful along with the calcareous foraminiferal genera Granuliferella, Endothyra, and Plectogyra found in the Kinderhook and Osage carbonate rocks of the same areas. Ostracodes and microcrinoids also commonly supplement the conodonts and Foraminifera.

The study reveals the potential value of micropaleontology in rocks of this age and points to the lack of documentation of recognized faunas for correlation, phylogenetic and environmental studies.--Auth.

3-2279. Mandra, York T. FOSSIL SILICOFLAGELLATES FROM CALIFORNIA, U.S.A. (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 6. Pre-Quaternary Micropaleontology, p. 77-89, 3 tables, 1960) 14 refs.

Silicoflagellates are defined here as marine, planktonic Mastigophora (Protozoa) with a flagellum and a skeleton of hollow siliceous rods. These organisms also contain color pigment organelles and therefore are treated by some authors as plants (algae) and by others as an animal-plant group (Protista).

Detailed observations of California fossil silicoflagellates have been made in order to find morphologic differences which have stratigraphic value. Faunules from the following California time-rock units were studied: 1 Upper Cretaceous shale; 2 upper Eocene "mudstones"; 1 middle Miocene, 1 upper Miocene, and 4 Mio-Pliocene diatomites. The most abundant faunules were found in diatomite. This rock seems to be the best natural medium for preserving fossil silicoflagellates. A total of 34 species were identified.

The genera Vallacerta and Lyramula are restricted to the Upper Cretaceous. The genus Naviculopsis and 5 species of other genera are confined to the upper Eocene. Seven species are restricted to the California Miocene. Hence, silicoflagellates at the generic and specific level do have value as another correlation tool.

Silicoflagellates are also useful as temperature indicators of present and ancient seas.--Auth.

3-2280. Barker, R. Wright. TAXONOMIC NOTES ON THE SPECIES FIGURED BY H.B. BRADY IN HIS REPORT ON THE FORAMINIFERA DREDGED BY H.M.S. CHALLENGER DURING THE YEARS 1873-1876. Accompanied by a Reproduction of Brady's Plates: Soc. Econ. Paleontologists & Mineralogists, Spec. Pub. no. 9, 238 p., 115 pls., Oct. 1960, 8 refs.

The 115 plates illustrating the Foraminifera described by Henry Bowman Brady in his "Challenger Report" of 1884 are reproduced. Notes on taxonomy changes and references to the literature where such changes were introduced correct the original descriptions. Four nomina nova are proposed: Fissurina wiesneri, Frondicularia kiensis, Robulus atlanticus, and Spiroplectella earlandi.--M. Russell.

3-2281. Phleger, Fred B. ECOLOGY AND DISTRIBUTION OF RECENT FORAMINIFERA: 297 p., 83 figs. incl. illus., charts, graphs, 11 pls., Baltimore, Johns Hopkins Press, 1960, approx. 200 refs.

This book summarizes the principal work done on the ecology of modern Foraminifera and attempts to integrate the results into a useful system. It is mainly a statement of progress and a definition of a field of study. Most of the work on Foraminifera has been on their taxonomy and their use as stratigraphic

markers for geologic correlation. The point of view expressed here is that Foraminifera are of value in problems of oceanography and paleoceanography.

It is hoped that the data and interpretations presented will be of value to both oceanographers and geologists and that they may be useful in helping to direct certain studies in oceanography, sedimentology of ancient marine rocks, and in related fields.

An attempt has been made to include all important research on ecology of modern Foraminifera already published.--From foreword.

Chapters deal with introduction and methods, depth distribution of benthonic Foraminifera, marginal marine distributions of benthonic Foraminifera, distribution studies of living benthonic Foraminifera, studies of planktonic Foraminifera, and summary discussion of geologic applications, oceanographic applications, and research problems.

3-2282. Copeland, M. J. OSTRACODA FROM THE UPPER SILURIAN STONEHOUSE FORMATION, ARISAIG, NOVA SCOTIA, CANADA: Palaeontology, v. 3, pt. 1, p. 93-103, pl., table, May 1960, 38 refs.

Several species of ostracods of the general Beyrichia, Kloedenia, Leperditia, and Primitia have been described from Upper Silurian strata of the Stonehouse formation near Arisaig, Nova Scotia. Previous identifications of some of these ostracods are considered doubtful due in part to the confusion arising from their original descriptions by James Hall. The present examination gives more detailed information concerning these previous species and reveals for the first time the presence of several species previously recorded only from northern Europe. On the basis of the contained ostracod fauna, correlation of the Stonehouse formation is made with the Beyrichia limestone of the Baltic region.--Auth.

3-2283. Ginsburg, Robert N. ANCIENT ANALOGUES OF RECENT STROMATOLITES (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 22. Proceedings of the International Paleontological Union, p. 26-35, 15 figs., table, 1960) 20 refs.

Recent algal biscuits that resemble ancient onkolites have long been known from fresh and brackish water. This paper describes the occurrence of algal biscuits that are forming in the intertidal zone and below sea level in Florida and the Bahamas.

These biscuits like the algal-laminated sediments of mud flats are formed by the alternation of sedimentation with the growth of a surface mat of filamentous blue-green algae. The mucilaginous mat traps and binds sediment on contact, and the motile filamentous algae move up through sediment lamina to form a new surface mat.

The domal biscuit-shaped growth form of convex-upward lamination is characteristic for these structures that originate on slight projections of the bottom. If, however, the biscuits are detached from the bottom and overturned, deposition of convex-upward laminations on their undersides forms a symmetric structure. Crenulations of the laminated structure are initiated by surface irregularities and perpetuated by convex-upward laminations.

To illustrate the use of the growth form, internal structure, and associated sediments of the recent algal biscuits for interpreting ancient biscuits or onkolites, 3 fossil examples are considered. The examples from the Devonian of Belgium (Gurich) and the Permian of Kansas (Twenhofel) were probably formed below sea level, and Precambrian example from Michigan is considered intertidal.--Auth.

3-2284. Banks, Harlan P. NOTES ON DEVONIAN LYCOPODS: Senckenbergiana Lethaea, v. 41, p. 59-88, illus., Aug. 1960.

This paper reviews the current status of many Devonian lycopods, emphasizing the contributions of Kräusel and Weyland that established unequivocally the framework of the group. On the basis of present knowledge, it is a discrete group and has been so since its earliest members appeared in Silurian time. Literature that has appeared since Kräusel & Weyland's review of 1949 is summarized, and 2 classifications of lycopods are included. New data on the occurrence of Archaeosigillaria, Protolepidodendron, Drepanophycus, and Colpodexylon in New York are presented along with information on a new flora from the Yukon Territory and a little recognized one in New Brunswick. The use of lycopods as index fossils and the course of evolution of lycopods along arborescent and herbaceous lines is discussed.--Auth.

3-2285. Bharadwaj, D. C., and B. S. Venkatachala. ON PROTOSALVINIA ARNOLDII N. SP. FROM UPPER DEVONIAN OF KENTUCKY, U. S. A.: Senckenbergiana Lethaea, v. 41, p. 27-35, illus., Aug. 1960.

Protosalvinia arnoldii n. sp. from the Upper Devonian of Kentucky, U.S.A., is distinguished by its rounded, unlobed head borne on a stalk. The head has a funnel-shaped depression, usually with a single spore cavity containing a single spore tetrad.--Auth.

3-2286. Radforth, Norman W., and John Walton. ON SOME FOSSIL PLANTS FROM THE MINTO COALFIELD, NEW BRUNSWICK: Senckenbergiana Lethaea, v. 41, p. 101-109, illus., Aug. 1960.

The age of the Minto coal flora is probably Westphalian C. [Pennsylvanian] and is the equivalent of the top of the Pottsville or base of the Allegheny in the United States. Two new genera and species of fossil plants, Bellopteris corsini and Mintopteris hirsuta, are described; the former is probably a pteridosperm and the latter a fern. The preservation is excellent, and further investigations of this flora will yield additional information of paleobotanical interest. The microfossils are abundant in the associated shales and offer a promising field for further research.--Auth.

3-2287. McGregor, D. C. DEVONIAN SPORES FROM MELVILLE ISLAND, CANADIAN ARCTIC ARCHIPELAGO: Palaeontology, v. 3, pt. 1, p. 26-44, 2 figs., 2 pls., table, May 1960, 41 refs.

Twenty-four species of spores are described from a bituminous coal of Melville Island. Of these, 20 species of small spores and 3 species of megaspores are new, and 2 of the latter represent new genera, Hystricosporites and Circumsporites. Evidence suggests that lycopsids were dominant constituents in the flora which produced the spores. The assemblage differs distinctly from those described by Naumova and may contain elements of an uppermost Devonian-lower Carboniferous flora, related to assemblages detected elsewhere in the Canadian Arctic. The geological significance of the assemblage is indicated.--Auth.

See also: Geologic Maps 3-2127 through 3-2139; Areal and Regional Geology 3-2150; Geomorphology 3-2190, 3-2191; Structural Geology 3-2197, 3-2212; Sedimentary Petrology 3-2372; Geohydrology 3-2382; Engineering Geology 3-2464.

3-2288. Aitken, M.J. PHYSICS AND ARCHAEOLOGY: 181 p., 49 figs. incl. diags., graphs, 28 pls., tables, New York, Interscience Publishers, 1961, refs.

Describes how the theory, practice and interpretation of the tools and methods of geophysics may be applied to the field of archeology. The scope is indicated by the following main chapter headings: 1) finding, 2) magnetic location, 3) the proton magnetometer, 4) resistivity surveying, 5) dating, 6) radiocarbon dating, 7) magnetic dating, and 8) analysis.

Data obtained by geophysical methods in archeological searches can be extremely useful in other fields, thus, magnetic data obtained for archeological evidence is vital to knowledge of the past behavior of the earth's magnetic field.--M. Russell.

3-2289. Tarkhov, A.G., and A.A. Sidorov. THE MATHEMATICAL PROCESSING OF GEOPHYSICAL DATA: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 10, p. 965-969, 5 figs., pub. 1961, 16 refs.

Different methods of mathematical processing should be applied to the results of geophysical observations with the object of decreasing the influence of the various types of interference. In addition to the calculation of the arithmetic and geometric means, the use of the so-called method of inverse probability has been recommended. It is shown, by applications to actual material, that the ratio (anomaly/interference) can be increased. The directions for possible future investigations are indicated.--Auth.

3-2290. Tuman, Vladimir S., and Dorothy Bollman. APPLICATION OF COMPUTERS TO THE INTERPRETATION OF WELL LOGS: Jour. Petroleum Technology, v. 13, no. 4, p. 311-318, 11 figs., 3 tables, Apr. 1961, 9 refs.

Available digital computers can be effectively used for the interpretation of well logs by the following procedure: 1) digitizing the well log data, 2) preparing the programs to process the data, and 3) analysis and evaluation of the results.

Types of available digitizing units are discussed. At present, the cost of digitization is greater than the cost of processing the same data by a computer. Consequently, further developments will be required to reduce the cost of getting the data in digital form.

An effort is made to indicate how to write a program for a digital computer, and a step-by-step example is worked out. Some examples processed on the computer for the formations in the Illinois basin are also included. Five programs prepared at the U. of Illinois are discussed. Detailed flow charts for 4 of these programs, including the "Discriminating Routine Program," are given. This program discriminates sands or porous beds from shales. It is the basic program for the automatic processing of the well logs which will control the over-all operation of the computer. It also can be used by geologists who are interested in sand/shale counts.

A rough economic study of the problem indicates that it will be advantageous to encourage service companies in the future to offer digitized well logs.--Auth.

3-2291. Afanasev, N.L. A DIRECT METHOD OF INTERPRETING ANOMALIES Δg: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 10, p. 987-990, 2 figs., pub. 1961, 5 refs.

The described method of interpretation enables the authors to find the desired parameters of the disturbing body: M, x_c, y_c, and z_c from the observed anomaly Δg found for finite limits. The accuracy of the determination of these parameters depends basically upon the correct choice of the limits of integration of the observed values of Δg. In practice, in order to obtain the desired values with an error not exceeding 3-5%, the width of the observed anomaly Δg should not be smaller than the double width of its most intensive part.--From auth., p. 990.

3-2292. Talwani, Manik, and others. GRAVITY ANOMALIES AND CRUSTAL SECTION ACROSS THE TONGA TRENCH: Jour. Geophys. Research, v. 66, no. 4, p. 1265-1278, 8 figs., 2 tables, Apr. 1961, 18 refs.

In 1956, gravity observations with the Vening Meinesz pendulum apparatus were made aboard H.M.S. Telemachus in the SW. Pacific Ocean. For each of several gravity profiles, large free-air anomalies were associated with the Tonga and Kermadec trenches. The seismic structure determined by Raitt, and others for the Tonga trench was projected to one of the gravity profiles. The gravity anomaly profile computed on the basis of the seismic structure is in fair agreement with the observed profile, but the 2 profiles differ by about 100 mgal. in the vicinity of the trench. Interposing a seismically 'masked' layer under the trench and increasing the crustal thickness there to 23 km. improves the fit. A crustal thickness of 36 km. is derived from gravity and seismic data for the Tonga-Kermadec ridge. The disagreement between this value and one obtained by Officer from surface wave dispersion data is discussed.--Auth.

3-2293. Sargent, John D. GEOPHYSICAL IMPLICATIONS OF VIKING EXPLORATION IN NORTH AMERICA (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 2. Geological Results of Applied Geochemistry and Geophysics, p. 179-181, 1960) 5 refs.

Considerable archeological, botanical, and historical evidence indicates that the Great Lakes region in North America was reinundated to a depth of more than 450 m. only 1,000 years ago. Viking explorers left evidence that makes possible the delineation of the shorelines of the resulting inland sea.

The reason for the existence of such a deep sea at such a recent date in the center of a continental land mass is isostatic oscillation. Continental ice depressed land surfaces at least 1,000 m. below sea level. Melting of the ice relieved the pressure and the land rose. Momentum of the land mass and underlying magmas caused overcorrection, past the point of isostatic equilibrium. The resulting elevation of the land mass was much too high to be in equilibrium and sank, again passing the point of equilibrium and caused the above mentioned inundation.

The name Henderson Sea is proposed for this body of water. We are still in the emergent phase of the Henderson Sea overcorrection.--Auth.

3-2294. Pechersky, D.M. ON THE QUESTION OF THE MAGNETIC ANISOTROPY OF LAYERED ROCKS:

Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 10, p. 995-998, table, pub. 1961, 8 refs.

Magnetic anisotropy is connected with layering of a given origin, that is, secondary layering created by the substantial one-sided pressures in conjunction with the high temperature. Metamorphic rocks, in particular the crystalline schists of the Precambrian and magnetic quartzites were examined. A similar layering is sometimes formed in the marginal parts of intrusives.

As a rule, no marked magnetic anisotropy is connected with the primary layering, created in the process of forming sedimentary, effusive and intrusive rocks.

A chaotic orientation of ferromagnetic minerals is primarily connected with the formation of fluidity in lavas, banding, lines of flow in intrusives; in crystallization they do not undergo markedly one-sided pressures. Hence the effect of the form, the crystallographic anisotropy of individual ferromagnetic minerals; their accumulation has a chance character, subject to the direction of the external magnetic field rather than to layering.

This does not refer to layers built entirely of ferromagnetic minerals. Here, of course, the role of the anisotropy of the form is very great. But such formations are not characteristic of eruptive and sedimentary rocks.

From the connection of the magnetic anisotropy with layering of a given nature there follows a very interesting hypothesis: the magnitude of the magnetic anisotropy of metamorphic rocks should reflect the degree of metamorphism. This hypothesis has been confirmed to a certain degree by the magnitudes of the ratios $I_{rt}^{n}/I_{rt}^{\perp}$ for rocks of different age and different degree of metamorphism: hornfels schists $T_1 \sim 1.0$; intrusive rocks of the Mesozoic - 1.06; hornfels schists of the Upper Devonian - 1.04; liparites of the Upper Devonian - 1.17; crystalline schists of the Sinian - 1.6; crystalline schists of the Proterozoic - 1.97.

The degree of metamorphism within the limits of one folded region reflects the relative age of the rocks. Consequently, a study of the magnetic anisotropy of metamorphic series of rocks may aid the relative age differentiation of them. The geological structure of such strata is very complex, and the problems of differentiating them is a most pressing one.--From auth. concl.

3-2295. Petrova, G.N., and V.A. Zhilyaeva. LABORATORY CRITERION OF THE MAGNETIC STABILITY OF ROCKS: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 9, p. 882-886, 7 figs., pub. 1961, 4 refs.

The existence of an interdependence between the magnetic stability of rocks during geological time and a laboratory-found parameter of stability H_c' has been established. An experimentally obtained curve, expressing the relationship between field stability S and parameter H_c' is adduced; in the case of rocks with a low magnetic stability, this curve enables us to reconstruct the position of the magnetic pole.--Auth.

3-2296. Socolow, Arthur A. GEOLOGIC INTERPRETATION OF CERTAIN AEROMAGNETIC MAPS OF LANCASTER, BERKS, & LEBANON COUNTIES: Pennsylvania Geol. Survey, Inf. Circ. 41, 19 p., 2 figs., 1961, 9 refs.

This publication deals with the interpretation and geologic correlation of aeromagnetic map patterns of 13 quadrangles: Womelsdorf, Sinking Spring, Ephrata, Terre Hill, Leola, New Holland, Gap, Lebanon, Richland, Manheim, Lititz, Columbia East, and Lancaster [see Sec. 1. Geologic Maps].

Lebanon and Richland quadrangles are of particular interest since they include the Cornwall Fe (magnetite) mines. The anomalies over the known ore bodies are surprisingly small in the light of the extensive known ore reserves. This is tentatively attributed to remnant polarization within the ore. The very limited nature of the magnetic anomalies over the known ore bodies is an inducement for careful evaluation of each magnetic anomaly in the region, no matter how small. A number of magnetic anomalies in the Cornwall area are designated as deserving further exploration for potential Fe concentrations, particularly those lying along an apparent lineament.

Gap quadrangle sedimentary, igneous, and metamorphic rocks are well defined by variations in magnetic patterns. One sharp magnetic anomaly is considered particularly worthy of exploration in view of its very close proximity to the Gap Ni deposit, a pentlandite-pyrrhotite bearing body of norite.

In the Womelsdorf quadrangle, although the sedimentary units show little magnetic variation, there is a gentle magnetic high over an area of Precambrian gneiss. Preliminary calculations indicate that the gneiss, an outlier of the Reading Prong, is very thin and may be part of a thrust sheet. No Fe concentrations of economic significance are indicated.

The Columbia East quadrangle has undergone intense structural deformation. Two magnetic highs may be related to disseminated magnetite in the Harpers-Antietam units which plunge beneath this area. There is no indication that these represent economically significant Fe concentrations.

In the Ephrata, Leola, Lititz, and Lancaster quadrangles there is very little magnetic variation inasmuch as the sedimentary units are of relatively uniform magnetic intensity. There is no indication of Fe ore concentrations of economic importance.

In the Sinking Spring, Terre Hill, New Holland, and Manheim quadrangles there are examples of positive magnetic anomalies related to diabase intrusives, ferruginous concentrations in Precambrian gneiss, and contact metamorphosed ferruginous sediments. No Fe concentrations of economic potential are indicated.--Auth.

3-2297. Hood, Peter J. PALEOMAGNETIC STUDY OF THE SUDBURY BASIN: Jour. Geophys. Research, v. 66, no. 4, p. 1235-1241, 4 figs., table, Apr. 1961, 21 refs.

A reconnaissance paleomagnetic study has been carried out on the Precambrian Ni eruptive of the Sudbury basin. A total of 60 oriented samples was collected along a single traverse across the northern range and along 4 traverses across the southern range of the basin. The remanent magnetism (RM) vectors of the 266 specimen cubes cut from the samples were subsequently measured with a 'spinner' magnetometer. The RM directions for the S. range are closely grouped on the Schmidt equal-area plot, and this fact indicates that there has been negligible relative rotary movement along the 16 mi. of the S. range sampled since the eruptive last cooled through the Curie point of its magnetic constituents. It was also found that the RM directions for the N. and S. ranges differ by approximately 40°, and this may be explained by assuming that there has been 40° of

relative tilting about an E.-W. axis through the middle of the basin. In 3 of the S. range traverses the susceptibility (κ) of the collected samples was higher on the S. end of the traverse than on the N. end, and in general the κ's obtained for the N. range were much higher than those obtained on the S. range. It would appear that the magnetic anomalies observed over the norite sections of the N. and S. ranges are mainly due to the presence of RM and to a lesser extent to an induced magnetization. The pole position calculated from the RM directions is dependent on the amount of assumed relative tilting. However if the rotation is equally divided between the 2 ranges, the resultant pole position is 38.4°N. 99.4°W., which is in the central U.S.--Auth.

3-2298. Troitskaya, V. A. EFFECTS IN EARTH CURRENTS CAUSED BY HIGH-ALTITUDE ATOMIC EXPLOSIONS: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 9, p. 877-881, 3 figs., 3 tables, pub. 1961, 12 refs.

Initial results are adduced of an analysis of short-period oscillations of the earth's electromagnetic field, caused by high-altitude atomic explosions in the S. Atlantic (operation "Argus") and in the region of Johnston I. (Pacific Ocean). The analysis was conducted according to rapid round-the-clock recordings, of terrestrial currents, with a feed of 30 mm./min., which had been conducted during the IGY in the Arctic, middle latitudes, and the Antarctic.--Auth.

3-2299. Roberts, P. H., and F. J. Lowes. EARTH CURRENTS OF DEEP INTERNAL ORIGIN: Jour. Geophys. Research, v. 66, no. 4, p. 1243-1254, 3 figs., 2 tables, Apr. 1961, 7 refs.

The current system flowing in the earth's core that is responsible for the dipole geomagnetic field is toroidal and does not appreciably extend into the mantle. However, the mechanism supporting these currents almost certainly generates in addition a poloidal current system that does extend into the mantle and that could, in principle, be measured at the earth's surface. In this paper the current distribution in the mantle is examined for several assumed distributions of conductivity in the mantle. The effect of the oceans is also briefly considered. It is found that the potential gradient at the surface of the earth associated with these deep earth currents may be of the order of a millivolt/kilometer if thermoelectric emf's at the core boundary contribute appreciably to the magnetic field, but will be smaller if the primary emf's are inside the core.--Auth.

3-2300. Atkins, E. R., Jr., and Gerould H. Smith. THE SIGNIFICANCE OF PARTICLE SHAPE IN FORMATION RESISTIVITY FACTOR-POROSITY RELATIONSHIPS: Jour. Petroleum Technology, v. 13, no. 3, p. 285-291, 5 figs., 3 tables, March 1961, 11 refs.

Results of laboratory tests are presented to show that the value of "m," in the Archie expression $1/F = \phi^m$, is determined by the shapes of the particles in the system. The value of m, "the shape factor," is constant for a system of particles of a given shape for a range of F - ϕ values. Applying this concept, one can predict F - ϕ relationships for mixtures of particles with different shapes, and these predicted relationships are useful in electric log interpretation.

It is suggested that an equation of the form $1/F = a\phi^m$ can be used to describe the properties of natural formations containing varying amounts of sand and clay. From this work and values of "a" and "m" reported in the literature, it appears that in many cases rocks in the same geological horizon have a common primary porosity but contain varying amounts of a particular clay. It is concluded that the equation can be applied to a rock-water system only when values of "a" and "m" have been established for the particular system.--Auth.

3-2301. Atkins, E. R., Jr. TECHNIQUES OF ELECTRIC LOG INTERPRETATION: Jour. Petroleum Technology, v. 13, no. 2, p. 118-124, 5 figs., Feb. 1961, 46 refs.

The generally used techniques of electric log interpretation are reviewed and discussed, including the determination of 1) formation water resistivity from the SP curve, 2) true resistivity values from log data, 3) water saturation from electric logs, and 4) formation porosity from resistivity data.

Particular emphasis is placed on the assumptions made in log interpretation. It is hoped that efforts will be stimulated which, in the future, will make it possible to reduce the number of assumptions necessary for log interpretation.--Auth.

3-2302. Schaub, Yu. B. APPLICATION OF THE METHOD OF A ROTATING MAGNETIC FIELD IN ELECTRICAL LOGGING: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 10, p. 991-994, 4 figs., pub. 1961, 3 refs.

The method of a rotating magnetic field can be employed not only in the search for ore bodies of high conductivity but also for electrical logging.

The variation in the lengths of the separations of the generating and receiving loops makes it possible to modify within a wide range the shape of the calibration curves, thus creating optimal conditions for solving concrete problems of the airborne electrical logging by the method under discussion.

In measuring 2 orthogonal components of the unbalance signal, it is possible to perform both the electrical logging of the enclosing media and prospecting for large bodies of ore of high conductivity. --Auth. concl.

3-2303. Dehlinger, Peter. SEISMOLOGY IN THE U.S.S.R.: Internat. Geology Rev., v. 3, no. 4, p. 279-324, Apr. 1961, 331 refs.

The purpose of this review is to establish a plateau from which Soviet seismology can be viewed, and to summarize Soviet published literature in seismology as of about Dec. 1959.

It appears that the Soviets are attempting to extend basic and applied knowledge in every phase of seismology. This approach has resulted in a systematic, well coordinated, and all-inclusive program in seismology that incorporates sizeable government agencies, a large number of highly trained scientists, and funds for operation which have been estimated to be considerably larger than those expended in the United States.

The major research and investigations in Soviet seismology are conducted at the Institute of Earth Physics (formerly the Geophysical Institute), and its field stations, of the U.S.S.R. Academy of Sciences. All phases of seismology are being studied at this Institute by a large staff of highly trained

scientists, including more than 100 geophysicists, physicists and mathematicians. The Institute also awards doctorate degrees in seismology. Other Soviet organizations are active in seismology, but to a lesser extent.

Among the main problems of Soviet seismology are the study of the physical properties of various types of seismic waves propagated in different media, especially layered media; the determination of criteria for recording and identifying wave groups; and the development of instruments to record, analyze, and process data. Some of the most significant Soviet developments during the last 15 years are mentioned.

For the purposes of this review, Soviet seismology has been grouped into 4 subjects: 1) theoretical and laboratory investigations, 2) earthquake seismology, 3) explosion seismology, and 4) instrumental seismology. Emphasis has been placed on principles, concepts, and techniques which the Soviets are using and developing, not on descriptions of particular earthquakes or prospecting areas. Under instrumental seismology, the broad instrumental developments only are discussed, not the details of individual instruments.--From introd.

3-2304. Archangelsky, V. T. QUESTIONS CONCERNING THE THEORY OF THE LONG-PERIOD VERTICAL SEISMOMETER: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 10, p. 955-960, 5 figs., pub. 1961, 7 refs.

The theory of suspension of the pendulum for a vertical seismometer is considered, and basic terms in the equation of motion of the pendulum are shown which give rise to its instability when its period is increased.--Auth.

3-2305. Rapoport, M.B. METHODS OF ULTRASONIC SEISMIC MODELING: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 9, p. 869-872, 5 figs., pub. 1961, 3 refs.

Inclusion of filters in a seismoscope to suppress the free oscillations of piezo-pickups eliminates the dependence of the form of the wave impulses on the degree of damping of the piezo-crystals, their contact with the model and other factors, and ensures the duplication of the form of the recording in all details.

Suppression of the free oscillations of the pickups by a filter makes it possible to use any given piezo-crystal, including even those poorly acoustically coordinated with the model, without being concerned about their damping.

Variation of the form (frequency and length) of the wave impulses is very useful in a number of cases; it is effected by a simple switching of the electric filters.

The use of piezo-pickups at frequencies substantially below their natural frequencies makes it possible to eliminate, for all practical purposes, the direction of the second kind and to regard the pickups as point elements.

The surface wave, which is an extremely intensive interference in modeling on solid models, may be many times weakened by coating the surface between the source and receiver with a thin layer of plasticin; it is further weakened by placing one of the pickups below the surface of the model.

The methodological procedures examined were used in modeling on solid 2-dimensional models, but to a considerable degree they are also suitable for 3-dimensional (liquid and solid) models.--Auth. concl.

3-2306. Bessonova, E.N., and others. INVESTIGATION OF THE MECHANISM OF EARTHQUAKES: Am. Geophys. Union, Soviet Research in Geophysics, in English translation, v. 4, 201 p., 78 figs., 4 tables, [1960], 110 refs.

The investigation of processes occurring at earthquake foci involves problems of seismology, geotectonics, and the mechanics of solid media. The solution of this problem is related to the main problems of seismology and seismogeology, primarily to the study of the conditions and causes of earthquakes, the relationship between seismic phenomena and tectonics, the physics of seismic waves, the structure of the earth, etc.

Earthquakes are direct manifestations of current tectonic movements at great depths. Therefore data regarding the fault plane displacement are of evident interest in the study of bathygenic tectonics.

From the point of view of methodology, however, the problem under investigation relates primarily to the dynamic theory of elasticity which permits, by means of seismic waves, a tie-in between processes at the focus and original data observable on the surface.

This book presents the results of work conducted by the Geophysics Institute of the Academy of Science, U.S.S.R., since 1948 on the investigation of fault plane displacements. During this period a method was evolved that makes it possible to determine the mechanical type of fractures at the focus, the dip and strike of the fault plane, and the direction of the displacement and order of the relative intensity of the first shock.

By means of this method it was possible to investigate the displacement near the foci of earthquakes in the seismic regions of the U.S.S.R. (the Garmskaya Oblast, northern Tien Shan, western Turkmenia, Kopet-Dag, and the Caucasus) and adjoining regions (Hindukush and the Pacific Ocean).

The first part contains the theoretical basis for, and a condensed description of, the methodology which, with the indicated references, may be used as a guide for the research seismologist.

The second part presents summary data regarding displacements near earthquake centers of the various seismic areas of the U.S.S.R. Basic determinations, when possible in geological terminology, are given at the beginning of the second part, so that the reader who is interested only in the tectonic aspect of the matter might dispense with Pt. I.

At the beginning of each section there is also a resumé of the results of previous works by other authors in the same field.

Many of the methodological conclusions and results of interpretations are being published for the first time.--From foreword.

3-2307. Arkhangelskaya, V.M. DISPERSION OF SURFACE WAVES AND CRUSTAL STRUCTURE: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 9, p. 904-927, 21 figs., 27 tables, pub. 1961, 72 refs.

This paper represents a synopsis of foreign publications which appeared during the last decade and which reflect the present status of crustal structure studies based on surface wave observations.

Presented are the results of determining the oceanic crustal structure in the basins of the Pacific, the Atlantic, Indian, and Arctic oceans, the Arctic

basin of the North Atlantic, and of the continental crust of Africa, North America, Europe, the Antarctic, Asia, and Eurasia. These results lead to conclusions as to the relative uniformity of the crustal structure both on the continents and in the oceanic basins.--From auth., p. 904.

3-2308. Shurbet, D. H. DETERMINATION OF SEDIMENTARY THICKNESS IN THE MEXICAN GEOSYNCLINE BY RAYLEIGH WAVE DISPERSION: Jour. Geophys. Research, v. 66, no. 3, p. 899-902, 2 figs., 2 tables, March 1961, 3 refs.

Dispersion of short-period Rayleigh waves is studied in an effort to measure sedimentary rock thickness in the Mexican geosyncline. The measurement is approximate, but the study indicates uniformity of crustal structure over a very large area, including the Mexican geosyncline. Therefore the study suggests an economical method of measuring crustal thicknesses over the entire area. The study indicates that the average sedimentary thickness across the Mexican geosyncline is about 8 km.--Auth.

3-2309. Popov, I.I. DISPERSION OF LONG-PERIOD LOVE WAVES IN THE CONTINENTAL AND OCEANIC CRUST ALONG THE PATH INDONESIA-CRIMEA: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no.10, p. 970-973, 4 figs., 2 tables, pub. 1961, 15 refs.

Presents the results of the experimental investigation of long-period surface waves in studying the crustal structure from seismological data.--Auth.

3-2310. Latter, Albert L., and others. A METHOD OF CONCEALING UNDERGROUND NUCLEAR EXPLOSIONS: Jour. Geophys. Research, v. 66, no. 3, p. 943-946, March 1961, 5 refs.

It is shown theoretically that the seismic signal from an underground nuclear explosion can be greatly reduced by carrying out the explosion in a large cavity. An estimate of the effectiveness of the method indicates that a yield of more than 300 kilotons (HE-equivalent) could be made to look seismically like a yield of 1 kiloton. Experiments with both chemical and nuclear explosions are needed to test the theory. --Auth.

3-2311. Herbst, Roland F., and others. USE OF LARGE CAVITIES TO REDUCE SEISMIC WAVES FROM UNDERGROUND EXPLOSIONS: Jour. Geophys. Research, v. 66, no. 3, p. 959-978, 19 figs., March 1961, 17 refs.

An analysis is given of an experiment designed to test the theory of seismic decoupling of underground explosions proposed by Latter, and others [see above]. The amplitude of the seismic signal from a 1.7-kiloton nuclear explosion in a hole in salt was calculated and compared with the measured value from the 1.7-kt. Rainier shot in tuff at the same distance. A decoupling factor of about 300 resulted. The experiment, called Cowboy, was designed to test the decoupling principle by carrying out a series of 8 high-explosive shots in 2 spheres made in a salt dome, and 9 tamped shots for comparison. The seismic data reported here were obtained primarily at ranges of 14,000 and 22,000 ft. and at frequencies of 10 to 30 c.p.s. A salt-to-salt decoupling factor of 100 was obtained which is consistent with the predicted tuff-to-salt factor of 300. When the sphere was overdriven so that the walls did not move elastically (which violates a condition of the theory for full decoupling), decoupling factors of 10 and 30 were measured. The seismic data are interpreted to give the dependence of decoupling on the various parameters of the experiment. The decoupling deduced from measurements made 80 ft. from the shot points is found to be consistent with that deduced from the measurements at 14,000 and 22,000 ft.--Auth.

3-2312. Murphey, Byron F. PARTICLE MOTIONS NEAR EXPLOSIONS IN HALITE: Jour. Geophys. Research, v. 66, no. 3, p. 947-958, 9 figs., 7 tables, March 1961, 5 refs.

Peak particle velocities and displacements were measured for tamped (coupled) and cavity (decoupled) explosions in halite. Recordings are illustrated of particle velocity versus time in the salt medium and of pressure versus time on the cavity wall. Peak particle velocities from tamped shots decrease as $d^{-1.65}$ over distances equivalent to 40 to 800 ft. for 1,000 pounds of high explosive.

Decoupling factors that were directly observed apply only to close-in stations. One method of extrapolating close-in data yields distant decoupling factors ranging from 40 to 100 for these particular experiments. Actual measurements of distant decoupling factors give larger numbers by a factor of 2. Extrapolation to nuclear explosions is not attempted here.--Auth.

3-2313. Adams, W. Mansfield, and others. SUMMARY REPORT OF STRONG-MOTION MEASUREMENTS, UNDERGROUND NUCLEAR DETONATIONS: Jour. Geophys. Research, v. 66, no. 3, p. 903-942, 26 figs., 25 tables, March 1961, 21 refs.

Subsurface and surface motion measurements were made on 6 underground nuclear detonations in the Oak Springs tuff of Nevada Test Site in Operation Hardtack II: Shots Mars (~13 tons), Tamalpais (~77 tons), Neptune (~115 tons), Logan (~5 kt), Evans (~30 tons), and Blanca (~19 kt.). Free-field peak radial acceleration decreased as the inverse third or fourth power of slant range, as for Rainier. Particle velocities attenuated at a rate between the inverse square and inverse cube. Maximum radial and tangential subsurface stress varied as the inverse cube of radial range. Observed peak strain suggested attenuation at a rate between inverse cube and inverse square of range. Maximum upheaval at Blanca surface zero was about 25.5 ft.;~2.5 ft. at 750 ft. radial range; and 1.5 ft. at 910 ft. Reed gage spectra indicated a shift of maximum energy to lower frequencies with increasing ground range. All components of surface acceleration followed an empirical equation of the form

$$A(g) = 3.2 \times 10^{6} W^{0.7} (kt.) R^{-2} (ft.).$$

All components of surface displacement did not follow a comparable relationship. Displacement is more precisely predicted than acceleration. The velocity of the tuff was determined to be 6,200 ft./sec., with the velocity of the underlying dolomite 11,700 ft./sec. If a 2-layer model for the crust beneath the Nevada Test Site is assumed, appropriate values for the thicknesses and velocities are 24 km. and 5.69 km./sec. for the top layer, and 36 km. and 7.65 km./sec. for the intermediate layer. The top of the mantle beginning at a depth of 60 km. has a velocity of 8.12 km./sec. and dips eastward.--Auth.

3-2314. Podyapolsky, G. S., and Yu. I. Vassilev. A RAYLEIGH-TYPE WAVE AT A NON-FREE SURFACE: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 9, p. 859-868, 7 figs., 2 tables, pub. 1961, 5 refs.

As a result of theoretical and experimental investigations, the existence has been established of a special type of head waves originating at the boundary of 2 half spaces under the conditions of a very sharp velocity (or density) contrast of the medium. These waves may be regarded as a generalized analogue of the Rayleigh wave (the latter corresponds to a degenerated case - a free surface).

Mathematically, they are related to a supplementary complex root of the denominator of the reflection coefficient at the boundary of 2 media, which root is, with a decrease in the acoustic impedance of one of the media, approaching the real root of the Rayleigh equation for a free surface of the second medium.

Rayleigh-type waves at a non-free surface (PRP, PRS, SRP, SRS) possess some certain characteristic peculiarities. Their velocity is close to the velocity of Rayleigh waves at a free surface of a medium having a high acoustic impedance. They are noted for their low-frequency spectrum, and decay rapidly with distance because of the energy emission from the medium having the greater acoustic impedance into the medium having the lesser acoustic impedance. In the medium with the greater acoustic impedance the displacement values diminish with distance from the interface of the media. The exponent of the function of divergence for the waves being analyzed is equal to 0.5, that is, it is the same as for the Rayleigh waves at a free surface and for the usual head waves in the case of a thin refracting layer. Let us point out that the usual Rayleigh wave at the (daylight) surface, because of the presence of an upper medium (air), should also in some certain cases be regarded as a Raleigh-type wave at a non-free surface.

During seismic exploration, the PRP and PRS waves can only be hindrances for the reflected waves and for certain types of head waves (for example, PSP and PSS), especially with the use of low-frequency or wide-band equipment. A sea or river bottom may present favorable conditions for their (PRP) originating (because of the presence not only of a velocity contrast, but also of a considerable density contrast between the bedrocks of the bottom and the water). --Auth. concl.

3-2315. Ogurtsov, K. I. EVALUATION OF THE INTENSITIES OF SEISMIC WAVES WHICH ARE REFLECTED FROM A VERY WEAK BOUNDARY OF SEPARATION: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 10, p. 951-954, pub. 1961, 2 refs.

The intensities of reflected waves are studied for vertical incidence with a consideration not only of the zero (acoustical) approximation, but also of the first approximation, which is the next term of the asymptotic series representing the solution. It is shown that in the case of a very "weak" boundary of separation, the first approximation may be comparable or even large in comparison with the zero approximation. --Auth.

3-2316. Starodubrovskaya, S.P. AN EXPERIMENTAL STUDY OF THE PECULIARITIES OF LONGITUDINAL WAVES REFLECTED FROM A THIN LAYER: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 10, p. 977-982, 5 figs., pub. 1961, 12 refs.

Based on the given analysis of the experimental data obtained in areas with varying depth of occurrence of the thin layer $h/\lambda_2 = 0.15$, $h/\lambda_1 = 0.3$ (f_{pr} = 50 c.p.s.) and $v_1/v_2 = 0.5$ along the interval from $x = 0$ to the nearest geophone the following can be concluded:

The wave reflected from a thin layer in both areas of investigation is dominant and can be easily correlated on the records.

The dynamic peculiarities of the wave, shape of the recorded wave, duration of oscillations and predominant periods do not change with distance from the source of excitation of the oscillations. Averaged amplitudes gradually attenuate with distance.

The waves recorded in areas with varying depth of occurrence of the thin layer are characterized by different predominant frequencies and different rates of attenuation of the amplitudes with distance. In the area where the thin layer occurs relatively shallow the reflected wave is characterized by higher predominant frequencies, but wave amplitudes attenuate with distance at a much lower rate than the wave amplitudes with the same frequency in the area with a thin layer occurring deeper.

Comparing the theoretical computations in the case of a reflection occurring from a thin layer and a half-space indicated that the differences noted in the shape of the recorded wave and the duration of the wave cannot be practically detected on the experimental seismograms in the given case.

Peculiarities of the shape of the recorded wave, duration of oscillations, variations of amplitudes are all noted on the experimental seismograms but are not distinctive indications of waves reflected from a thin layer due to the fact that they are equally characteristic of waves reflected from the boundary of a thick layer.

Problems are not discussed concerning spectral peculiarities and absolute magnitudes of wave amplitudes in the case of a reflection from a thin layer and a reflection from a half-space. In connection with the above statements, the conclusions are incomplete concerning wave differences in the case of a thin layer and a half-space, and, apparently there are other possible criteria for distinguishing waves reflected from a layer and a half-space. --Auth. concl.

3-2317. Berg, Joseph W., and others. SEISMIC PROFILES IN NORTHWESTERN UTAH: PILOT RANGE AND GROUSE CREEK RANGE AREA: Jour. Geophys. Research, v. 66, no. 4, p. 1255-1263, 6 figs., Apr. 1961, 12 refs.

Two seismic refraction profiles were established in northwestern Utah. The first, which extended along the area lying E. of the Pilot Range, was about 55 km. in total length and extended S. from about 10 km. SE. of Lucin, Utah, to about 13 km. N. of Wendover, Utah. The second, which extended N. into the area W. of the Grouse Creek Range, was about 95 km. in total length and extended N. from a point about 15 km. N. of Wendover to the vicinity of the town of Grouse Creek, Utah. The 2 profiles were reversed for about 47 km. of the distance. Commercial seismic prospecting equipment, modified to pass frequencies between about 3 and 50 c.p.s., was used.

Results of this study showed that materials having velocities of about 2.0, 5.5, 6.2, and 7.4(?) km./sec. exist at depths of about 0, 0.8, 4, and 24 km., respectively. The apparent dips of the 5.5- and 6.2-km./sec. horizons were about 1/4°N. and 2 1/2°N., respectively. Reflections from the horizon at an approximate depth of 24 km. were identified on seis-

mograms taken at 5 of the recording locations. A second reflection, which could result from a reflecting horizon at a depth of about 27 km., was identified on 4 of the 5 seismograms.--Auth.

3-2318. Zharkov, V.N. THE PHYSICS OF THE EARTH'S CORE. THERMODYNAMIC PROPERTIES. I: Akad. Nauk SSSR, Izvestiya, Geophysics Ser., in translation, 1960, no. 10, p. 945-950, 5 figs., 3 tables, pub. 1961, 13 refs.

Thermodynamic parameters for models of a silicate and Fe core are determined. The contribution on the part of conduction-electrons to thermodynamic parameters has not been taken into account, since this problem was discussed in previous articles.--Auth.

3-2319. Cheremensky, G.A. THE ZONE OF DISTURBANCE OF THE THERMAL STATE OF ROCKS BY DRILLING A BOREHOLE: Akad. Nauk SSSR, Isvestiya, Geophysics Ser., in translation, 1960, no. 10, p. 1008-1009, fig., pub. 1961, 2 refs.

The diameter of the zone of disturbance of the thermal state of rocks found by drilling a borehole depends upon the length of the drilling, the temperature of the drilling liquid, the thermal properties of the rocks, plus the geological and hydrogeological features of the region, etc.

The theoretical calculations made, confirmed by experimental observations, indicate that zones of disturbance of the thermal conditions 10-20 m and more in diameter may be formed.

The existence of substantial zones of disturbance of the thermal state of rocks about boreholes causes a slow heating (cooling) of the drilling liquids in the boreholes, which, when the temperatures are measured with a low degree of accuracy, may be erroneously taken as the restoration of the thermal conditions disturbed by the drilling.--Auth. concl.

3-2320. Clark, Sydney P., Jr., HEAT FLOW FROM A DIFFERENTIATED EARTH: Jour. Geophys. Research, v. 66, no. 4, p. 1231-1234, 2 tables, Apr. 1961, 8 refs.

Calculations are made of the heat flow from an initially cold earth with radioactivity distributed uniformly through a surface shell, with account taken of radioactive decay. It is found that the heat flow exceeds the heat produced by about 10% if the abundances of radioactive elements are the same as in chondrites and the radioactive shell is less than about 300 km. thick. The heat flow calculated in this way exceeds the observed value, but neither figure is considered known accurately enough to warrant rejection of the chondrite model of the earth.--Auth.

7. GEOCHEMISTRY

See also: Geomorphology 3-2185; Mineralogy 3-2335; Igneous and Metamorphic Petrology 3-2356; Geohydrology 3-2383, 3-2384; Mineral Deposits 3-2403 through 3-2409.

3-2321. GEOKHIMIYA. GEOCHEMISTRY; A TRANSLATION OF THE JOURNAL OF THE ACADEMY OF SCIENCES, U.S.S.R., DEVOTED TO GEOCHEMISTRY: 1956, no. 1-8, pub. 1960.

CONTENTS:

No. 1.

Vinogradov, A. P. Regularity of distribution of chemical elements in the earth's crust.

Kapustinsky, A. F. Geospheres and chemical properties of atoms.

Khitarov, N. I. The 400° isotherm for the system H_2O-SiO_2 at pressures up to 2,000 kg/cm^2.

Beus, A. A. Characteristics of the isomorphous entry of beryllium into crystalline mineral structures.

Tauson, L. V., and L. A. Kravchenko. Characteristics of lead and zinc distribution in minerals of Caledonian granitoids of the Susamyr batholith in central Tian-Shan.

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Malyuga, D. P., and A. I. Makarova. An experiment in biogeochemical prospecting of ore deposits in the autonomous territory of Tuva.

Germanov, A. L. A possible hydrochemical cause for development of a subzone of leaching.

No. 2.

Vinogradov, A. P., and A. B. Ronov. Evolution of the chemical composition of clays of the Russian platform.

Starik, I. E., and M. M. Shats. Determination of uranium in stony and iron meteorites.

Petrzhak, K. A., and others. Isotopic composition of uranium in meteorites.

Vainshtein, E. E., and others. Regularities in the distribution of rare earths in certain minerals.

Shcherbina, V. V., and L. I. Ignatova. Formation and solution of autunite.

Baranov, V. I., and G. Tleuberghenova. Application of the microradiographic method utilizing liquid emulsions to a study of the content and distribution of radioactive elements in rocks.

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Khitarov, N. I., and E. V. Rengarten. Geochemistry of carbonic acid in granitic intrusions.

Yavnel, A. A. Regularities in the composition of meteorite substance and a classification of iron meteorites.

Tauson, L. V., V. I. Vernadskii Memorial Conference.

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No. 3.

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Teis, R. V. Isotopic composition of oxygen in natural sulfates.

Florensky, K. P. Relationship of inert gases and nitrogen in natural gases.

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Dmitriev, L. V. Chemical peculiarities of crystallization of granites of the main intrusive phase of the Kaib massif.

Shcherbina, V. V. Geochemical significance of

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Ginzburg, A. I. Certain features of geochemistry of tantalum and types of tantalum enrichment.

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Baranov, V. I. V Session of the Committee on Determination of Absolute Age of Geologic Formations.

No. 4.

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Manskaya, S. M., and others. Binding of uranium by humine acids and by melanoidines.

Naumov, G. E., and K. I. Tobelko. Some experiments on the artificial synthesis of nasturan (pitchblende).

Tugarinov, A. I., and others. Hafnium-zirconium ratio in the zircons of igneous and metasomatic rocks.

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Dmitriev, L. V., and E. B. Znamensky. Distribution of titanium in granites.

Ginzburg, I. I., and K. M. Mukanov. Distribution of Pb, Zn and Cu in different size ranges and density fractions of hill wash in two mineralized localities of central Kazakhstan.

Alekseev, A. A. Fluorine in thermal springs of low mineral content.

Polyakova, M. N. Geochemistry of iodine in the ground waters of the Crimean steppe.

Sveshnikov, G. B., and S. L. Dobychin. Electrochemical solution of sulfides and dispersion aureoles of heavy metals.

Ivanov, A. K. Memorial of Vladimir Afanasevich Obruchev.

No. 5.

Vinogradov, A. P. Comparison of data on the age of rocks obtained by different methods and geological conclusions.

Starik, I. E. The role of secondary processes in age determination by radiometric methods.

Gerling, E. K. The argon method of age determination and its application to the subdivision of the Precambrian formations of the Baltic and Ukrainian shields.

Polevaya, N. I. The absolute age of some igneous complexes of the USSR according to the argon method data.

Shcherbina, V. V. Complex ions and the transfer of elements in the supergene zone.

Gerasimovsky, V. I. Geochemistry and mineralogy of nepheline syenite intrusions.

Beus, A. A. Geochemistry of beryllium.

No. 6.

Vinogradov, A. P., and A. B. Ronov. Composition of the sedimentary rocks of the Russian platform in relation to the history of its tectonic movements.

Strakhov, N. M., and others. Types of distribution of dispersed amounts of elements in sediments of the humid zones.

Valyashko, M. G. Geochemistry of bromine in the processes of salt deposition and the use of the bromine content as a genetic and prospecting criterion.

Sobolev, V. S. Relation between the properties of silicates and their structure.

Dontsova, E. I. Isotopic composition and exchange equilibria of oxygen in the lithosphere.

Boky, G. B. Principles of classification of chemical compounds, including minerals.

Lemmlein, G. G. Formation of fluid inclusions in minerals and their use in geological thermometry.

No. 7.

Korzhinsky, D. S. Dependence of activity of components upon the solution acidity and reaction sequence in postmagmatic processes.

Tauson, L. V., and others. Uranium distribution in the granitoid complex of the Sussamyrsk batholith, central Tian-Shan.

Morachevsky, Y. V., and L. I. Belyaeva. On the composition of uranovanadates.

Ostroumov, E. A., and V. M. Shilov. Distribution of sulfides of iron and hydrogen in deep sediments in the northwestern Pacific Ocean.

Zhirov, K. K., and S. I. Zykov. Metamorphism and the time of formation of granites as based on isotopic analyses of lead.

Zhirov, K. K., and S. I. Zykov. Genesis of some lead deposits in the light of data of isotopic analysis.

Gerling, E. K., and L. K. Levsky. Origin of inert gases in stony meteorites.

Rabinovich, A. V., and others. Isotopic composition of lead in some rocks and in galenas related to those rocks.

Rafalsky, R. P. The action of hydrothermal sulfidic solutions on arsenides of cobalt and nickel.

Gerasimovsky, V. I. Mineralogical characteristics of uranium deposition in the oxidized zone of the Shinkolobwe ore deposits.

No. 8.

Vinogradov, A. P., and others. C^{14} age determinations.

Yakhontova, L. K., and P. A. Raudonis. Oxidation of certain arsenides of cobalt, nickel, and iron, and also of their double mixtures.

Naydin, D. P., and others. Determination of the climatic conditions of some regions of the USSR during the Upper Cretaceous period by the method of isotopic paleothermometry.

Zykov, S. I., and N. I. Stupnikova. Determination of the age of a pegmatite vein of the Koita-tundra by cyrtolite, allanite and uraninite.

Starik, I. E., and others. Luminescent determination of uranium in rocks and minerals.

Leonova, L. L. A luminescent method of determination of small amounts of uranium in igneous rocks.

Florensky, K. P. Classification of natural gases on the basis of features diagnostic of their origin. I. Gases of supergene type.

Kuznetsov, V. I. Data on chemical analyses of minerals of the isomorphous series columbite-tantalite.

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CONTENTS:

No. 1

Vinogradov, A. P., and others. Isotopic composition of ore lead from Altai and Kazakhstan.

Baranov, V. I., and L. A. Kuzmina. Content of radioactive elements in bottom sediments of Pacific Ocean in the area of Japanese islands.

Murin, A. N., and I. A. Yutlandov. The determination of the cosmic age of meteorites.

Barsukov, V. L. The geochemistry of tin.

Kozlova, O. G. Rare earths in fluorites from different USSR localities.

Malinin, S. D. The solubility of lead chloride in liquid and vapor phases of water.

Ivanov, V. V. The present hydrothermal activity of the volcano Ebeko on the isle of Paramushir.

Kaliuzhnyi, V. A. Results on pH measurements in solutions from liquid inclusions.

Albov, S. V. On the problem of boron in ground waters of Crimea.

Bughelsky, Y. Y. Some characteristics of zinc, lead and copper migration in ground waters in complex ore deposits of central Kazakhstan.

Shcherbina, V. Meeting of the All-Union Mineralogical Society.

No. 2.

Khristianov, V. K., and others. Boron content determination by the neutron method under field conditions.

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Znamensky, E. B. On the distribution of titanium in granites.

Studennikova, E. V., and others. On the distribution of molybdenum in intrusives.

Vinogradov, V. I. On the migration of molybdenum in the supergene zone.

Baranova, V. V. Aureoles of molybdenum dissemination in one section of the Tyrny-Auz mineral district.

Lipova, I. M., and others. On the ratio of zirconium and hafnium in granitoids of the Verkhissetsk intrusion.

Starik, I. E., and others. Determination of plutonium ratio in pitchblende.

Zhirov, K. K., and others. On durability of bonds of different lead isotopes in the structures of allanite.

Baranov, V. I. On the age of meteorites.

Lebedev, A. P. The geochemistry of carbon in Siberian trap rock and certain other basic rocks of the USSR.

Turovsky, S. D. Geochemistry of uranium and thorium.

Krinov, E. L. The Seventh Conference on Meteorites.

No. 3.

Vinogradov, A. P., and others. Some data on the isotopic composition of sulfur in sulfides.

Gerling, E. K., and Y. A. Shukolyukov. Determination of the absolute age from the ratio of isotopes Sr^{87}/Sr^{86} in sedimentary rocks.

Golubchina, M. N., and others. Isotopic composition of thallium in igneous rocks.

Sardarov, S. S. Retention of radiogenic argon in microcline.

Golubchina, M. N., and A. V. Rabinovich. Criteria of relationship between mineralization and magmatism based on the isotopic analysis of lead in the country rock and in the ore.

Starik, I. E., and L. B. Kolyadin. The occurrence of uranium in ocean water.

Ershova, Z. P., and Y. I. Olshansky. Equilibrium of immiscible liquids in systems of the MeF_2-MeO-SiO_2 type.

Znamensky, E. B., and others. Distribution of niobium and tantalum in granites.

Zabavnikova, I. I. Diadochic substitutions in sphene.

Vinogradov, V. I. Solubility of the secondary molybdenum minerals in the weak solutions of H_2SO_4 and Na_2CO_3.

Yakhontova, L. K., and A. P. Grunev. Experimental study of cobalt-nickel diadochy in arsenates.

Naboko, S. I., and V. G. Silnichenko. Formation of silica gel on the solfataras of Golovnin volcano on Kunashiri island.

Rekharsky, V. I. Zoning in hydrothermal alteration halos near veins of rare metals.

Khitarov, N. I. Coesite, a new modification of silica stable at high pressures, and the problems related to it.

Gerasimovsky, V. I. Meeting in memory of V. I. Vernadskii (94th anniversary of birth).

No. 4.

Teis, R. V., and others. Determination of paleotemperatures from the isotopic composition of oxygen in calcite of certain Cretaceous fossil shells from Crimea.

Borodin, L. S., and I. I. Nazarenko. Chemical composition of pyrochlore and diadochic substitutions in the $A_2B_2X_7$ molecule.

Ershova, Z. P. Equilibrium of immiscible liquids in the systems of the MeF_2-Al_2O_3-SiO_2 type.

Gerling, E. K., and I. M. Morozova. Determination of activation energy of argon liberation from micas.

Barsukov, V. L., and G. E. Kurilchikova. Conditions of formation of endogenic ascharite.

Vershkovskaya, O. V., and E. A. Fabrikova. Gallium in sphalerite.

Shilin, L. L., and L. P. Tsareva. On the abundance of beryllium in rocks and minerals of pegmatites from the Lovozero and Khibina tundra.

Gerasimovsky, V. I., and N. V. Turanskaya. The high content of lanthanum and cerium in minerals of the agpaitic syenites of the Lovozero massif (Kola peninsula).

Volkov, I. I., and E. A. Ostroumov. The form of sulfur compounds in the interstitial waters of the Black Sea sediments.

Posokhov, E. V. Concerning A. A. Alekseev's paper, "Fluorine in acratothermal springs."

No. 5.

Pavlenko, A. S., and others. On the hafnium-zirconium ratio in zircons of igneous and metasomatic rocks.

Borovik-Romanova, T. F., and A. F. Sosedko. Spectrographically determined rare alkali content in pegmatites of the Kola peninsula.

Khitarov, N. I., and others. Experiments in melting granite in the presence of water.

Naboko, S. I. A case of gaseous fluorine metasomatism at an active volcano.

Barsukov, V. L. and G. E. Kurilchikova. The boron content of serpentinites.

Kraynov, S. R. The feasibility of applying hydrochemical methods to the solution of certain of metallogenesis.

Lurye, A. M. Certain regularities in the distribution of elements in sedimentary rocks of the northern Bayaldyr district in central Karatau.

Slepnev, Y. S. Geochemical peculiarities of the lovochorriterinkolite pegmatites of the Khibina alkaline massif.

Gerasimovsky, V. I., and others. On the ratio of niobium and tantalum in nepheline syenites of the Lovozero alkalic massif.

Korolev, D. F. Some peculiarities of molybdenum distribution in rocks of the Bylymsk coal deposits.

Akishin, P. A., and others. A new effective ionic emitter for the isotopic analysis of lead.

Zykov, S. I., and N. I. Stupnikova. Isotopic analysis of lead not requiring any preliminary chemical preparation of the mineral.

Knorre, K. G., and Z. V. Studennikova. VI Session of the Commission on Determination of Absolute Ages of Geologic Formations.

No. 6.

Vinogradov, A. P. Outline of the history of geochemistry in the USSR.

Vinogradov, A. P., and others. Content of inert gases in the Sikhote-Alin iron meteorite.

Ronov, A. B., and Z. V. Khlebnikova. Chemical composition of the main genetic clay types.

Valyashko, M. G. Physico-chemical conditions of the formation of potassium salt deposits of the past.

Khitarov, N. I. The chemical properties of solutions arising as a result of the interaction of water with rocks at elevated temperatures and pressures.

Shcherbina, V. V. Behavior of uranium and thorium in the sulfate-carbonate and phosphate environments of the supergene zone.

Lebedev, V. I. Some factors in the migration of alkali and alkali earth elements in the supergene zone.

Ostroumov, E. A., and I. I. Volkov. The relationship between phosphorus, vanadium and organic matter in the Black Sea deposits.

Miller, A. D., and V. Y. Danilov. Salt dispersion haloes of rare-metal pegmatites in the Kola peninsula.

Makedonov, A. V., and N. I. Rodnyi. The composition of the lower Permian sedimentary formations in the Pechora coal basin.

Yavnel, A. A. The composition of the Tunguska meteorite.

No. 7.

Vinogradov, A. P., and others. Age of Precambrian rocks of the Ukraine.

Komlev, L. V., and others. Age of geologic formations in the southwestern part of the Ukrainian Precambrian.

Studennikova, Z. V., and K. G. Knorre. Age of north Caucasian granites.

Baskova, Z. A., and G. I. Novikov. The evolution of small amounts of lead by a reducing calcination in vacuum.

Starik, I. E., and others. Modes of lead occurrence in nature.

Zhirova, V. V., and others. The age of pegmatites of the Slyudyanka region.

Tauson, L. V., and N. N. Buzaev. Geochemistry of thallium in granitoids of the Susamyr batholith, central Tian-Shan.

Voskresenskaya, N. T., and T. D. Usevich. The occurrence of thallium in manganese minerals.

Kapitanov, Y. T., and A. S. Serdyukova. An experiment in utilization of alpha-count methods for determination of absolute geologic age of rocks.

Kostyleva, E. E., and T. K. Sukhushina. The pH values of ore quartz suspensions.

Semenov, E. I. Isomorphism and camouflage of rare earths.

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Palei, I. P. The concentration of native selenium in the oxidized zone of a pyrite deposit.

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No. 8 in this volume has not yet been published.

3-2323. Barnett, Paul R. AN EVALUATION OF WHOLE-ORDER, 1/2-ORDER, AND 1/3-ORDER REPORTING IN SEMIQUANTITATIVE SPECTROCHEMICAL ANALYSIS: U. S. Geol. Survey, Bull. 1084-H, p. 183-206, 3 graphs, 6 tables, 1961, 6 refs.

The results of 507 spectrochemical determinations in 63 samples are evaluated by the percentage of successful assignments to the correct range and by calculation of the logarithmic standard deviation. The intervals in terms of the standard deviation are approximately the same whether computed by the percentage of hits or by the usual method for replicate determinations (after converting the data to logarithms). The size of the reporting interval is from 4 to 6 times the standard deviation for the whole order, 2.7 times the standard deviation for the 1/2-order, and still approximately twice the standard deviation for the 1/3-order of magnitude breakdown. --Auth.

3-2324. General Electric Company, Hanford Atomic Products Operation, Richland, Washington. DETERMINATION OF THORIUM IN URANIUM ORES. By R.Ko and M.R. Weiler: U.S. Atomic Energy Comm. [Pub.] HW-66220, Contract AT(45-1)-1350, 17 p., 4 tables, Sept. 1960, 20 refs.

A method was developed for the determination of 1 p.p.m. of Th in 1 g. of U ore. Th was separated by lanthanum fluoride precipitation and TTA extraction. The final solution was analyzed spectrographically after adding Zr internal standard. The precision of the method expressed as a coefficient of variation was $\pm$ 12% at 1 p.p.m. Th-234 tracer recovery was 84%.--Auth. summ.

3-2325. Krinov, E. L. THE NATURE OF MICROMETEORITES: Am. Jour. Sci., v. 259, no. 5, p. 391-395, 6 figs., May 1961, 17 refs.

The author believes that meteorite showers are usually caused by the fragmentation of one large meteorite in its rapid course through our atmosphere, rather than by the invasion of a swarm of initially discrete particles. In the process of fracture many small particles, including microscopic dust particles, must get separated from the main mass. These small particles have the fusion crust and morphological properties of meteorites in general. They differ from cosmic dust that enters the atmosphere directly from interplanetary space in that the cosmic dust particles are practically unaltered by impact with our atmosphere.--D. Hoffleit.

3-2326. Goles, Gordon G., and Edward Anders. THE RECORD IN THE METEORITES. 6. ON THE CHRONOLOGY OF THE EARLY SOLAR SYSTEM: Jour. Geophys. Research, v. 66, no. 3, p. 889-898, 2 figs., table, March 1961, 31 refs.

An attempt is made to account for the differences between the isotopic composition of terrestrial and meteoritic Xe reported by Reynolds. The 2 chief mechanisms proposed (other than the decay of I^{129} to Xe^{129}) are the production of $Xe^{131-136}$ by spontaneous fission of extinct nuclides in the earth, and the production of $Xe^{124-128}$ by nuclear spallation reactions in the early history of the solar nebula. About 9.6% of the Xe^{136} in the earth's atmosphere appears to have arisen from the spontaneous fission of 76-million-year Pu^{244}, as proposed by Kuroda. The Pu^{244}-Xe^{136} decay interval of the earth is 290 m.y., and its I^{129}-Xe^{129} decay interval may be estimated as $\geq$210 m.y. Thus, the earth appears to be 100-200 m.y. younger than the meteorites. Possible errors in these determinations are discussed. A dating method, similar to the Pb^{207}-Pb^{206} method and based upon the 2 decay systems I^{129}-Xe^{129} and Pu^{244}-Xe^{136}, is proposed and the appropriate equations are given. The initial solar-system ratios of I^{129}/I^{127} and Pu^{244}/U^{238}, which can be determined

by this method, would provide a crucial test of models of nucleosynthesis.--Auth.

3-2327. Mason, Brian H., and H. B. Wiik. THE TOMHANNOCK CREEK, NEW YORK, CHONDRITE: Mineralog. Mag., v. 32, no. 250, p. 528-534, illus., Sept. 1960.

The Tomhannock Creek chondrite has been analyzed, with the following results: Fe 11.36, Ni 1.69, Co 0.07, FeS 5.26, SiO_2 36.88, TiO_2 0.135, Al_2O_3 1.80, Cr_2O_3 0.30, FeO 14.94, MnO 0.31, MgO 23.81, CaO 1.39, Na_2O 0.73, K_2O 0.095, P_2O_5 0.36, H_2O+ 0.34, C 0.10; total 99.57. The mineralogical composition is olivine (Fo_{81}), hypersthene (En_{83}), plagioclase (An_{22}), Ni-Fe, troilite, chromite, and probably apatite. The density of the meteorite is 3.65.

Tomhannock Creek is not identical with Homestead, nor with Yorktown. Yorktown is a chondrite that appears to have fallen near Yorktown, Westchester County, New York (41°17'N. 73°49'W.), in Sept. 1869.--Auth.

3-2328. Shedlovsky, J. P. COSMIC-RAY PRODUCED MANGANESE-53 IN IRON METEORITES: Geochim. et Cosmochim. Acta, v. 21, no. 1/2, p. 156-158, table, Dec. 1960, 14 refs.

The radioactivity of Mn has been measured in the Odessa, Grant, and Williamstown meteorites. Mn was first isolated chemically and the β radiation counted. As a control γ radiation was counted; this check showed that gamma-emitting Mn^{54} was absent in the meteorites examined. The activities found are greater than the levels predicted by Sheline and are ascribed to cosmogenic Mn^{53}.--F. Manheim.

3-2329. Sullivan, Walter. GLASSY DEBRIS ON EARTH LINKED TO ANCIENT ASTEROID EXPLOSIONS: New York Times, v. 110, no. 37,712, p. 18, col. 3-6, Apr. 25, 1961.

The finding of metallic particles similar in composition to meteorites within tektites would appear to confirm the theory that tektites are the result of asteroids colliding with a large body such as the earth or the moon. Most tektites fall into 1 of 3 age groups – 600,000 years, 8,700,000 years, and 30,000,000 years – suggesting that all tektites found so far resulted from 3 such collisions. Several large craters are tentatively related to known tektite finds.--M. Russell.

3-2330. Chow, Tsaihwa J., and Edward D. Goldberg. ON THE MARINE GEOCHEMISTRY OF BARIUM: Geochim. et Cosmochim. Acta, v. 20, no. 3/4, p. 192-198, 3 figs., 3 tables, Nov. 1960, 13 refs.

The Ba content of sea water from the Pacific Ocean has been determined by an isotope dilution technique. A marked increase in the concentration of Ba with depth was found at all stations, with values ranging from 10 to 63 μg./l. The increase with depth is attributed to organisms and detrital organic matter. The solubility of $BaSO_4$ in sea water at 1 atm. and 25°C. was calculated to be approximately 52 μg./l., the solubility decreasing with temperature and increasing with pressure. It is concluded that Ba is not saturated in surface waters of the Pacific, but that saturation levels may be reached at depth.--F. Manheim.

3-2331. Park, R., and Samuel Epstein. CARBON ISOTOPE FRACTIONATION DURING PHOTOSYNTHESIS: Geochim. et Cosmochim. Acta, v. 21, no. 1/2, p. 110-126, 4 figs., 13 tables, Dec. 1960, 18 refs.

The mechanism of C isotope fractionation during photosynthesis has been studied experimentally by determining C^{13}/C^{12} ratios on living plants grown under controlled conditions. Many aspects of the variation of C^{13}/C^{12} ratios can be explained on the basis of a 2-step model. The first step is the fractionation involved in the absorption of CO_2 from the atmosphere by the leaf. The second step is the enzymatic conversion of dissolved CO_2 in the cytoplasm to carbohydrates.

Greater C^{12} enrichment in the plant tissue occurs at high CO_2 concentrations. Light intensity did not have an important influence over the intensity ranges studied. The CO_2 respired in early stages of respiration has higher C^{13} content than that respired later. This is associated with the loss of dissolved CO_2 which predominates during the earlier stages, in contrast to the destruction of lipids which contribute increasing amounts of CO_2 in the later stages. The model made it possible to explain isotopic differences between land and marine plants, between lichens and higher plants, and to account for the unexpected C^{13}/C^{12} ratios of the calcareous skeleton of algae.--F. Manheim.

8. MINERALOGY AND CRYSTALLOGRAPHY

See also: Igneous and Metamorphic Petrology 3-2360; Mineral Deposits 3-2416, 3-2420.

3-2332. Gore, Dorothy J. THE NEW MINERALOGY-PRINCIPLES AND EXPLANATIONS OF MINERAL PROPERTIES: Jour. Geol. Education, v. 9, no. 1, p. 29-31, Spring 1961.

An important aim of a course in mineralogy is to show, on the basis of crystal chemistry, why mineral properties exist as they do. The coordination principle of crystal chemistry explains crystal structure and chemical-element ratios; the substitution principle explains solid solution, and thus the many departures from ideal formulas found in minerals; the principle of bonding forces explains hardness and directions of cleavage. Other principles of significance are those of abundance and anion dominance.

Having learned the "why's" of mineral properties, most students can predict the physical properties of a mineral if told the composition and structure.--Auth.

3-2333. Bown, M. G., and P. Gay. AN X-RAY STUDY OF EXSOLUTION PHENOMENA IN THE SKAERGAARD PYROXENES: Mineralog. Mag., v. 32, no. 248, p. 379-388, illus., March 1960.

The single crystal X-ray methods for the study of exsolution phenomena in pyroxenes previously described by the authors have been applied to the pyroxenes of the Skaergaard intrusion. The results for about 50 pyroxene crystals, selected from various

levels between the chilled margin and a height of 2,600 m. in the layered series, are presented and are correlated with previous optical descriptions. While the correlation between the results of the optical and X-ray examinations is in general satisfactory, the present investigation shows that the X-ray techniques can in some cases extend our knowledge of the Skaergaard pyroxenes.--Auth.

3-2334. Mineral Research Society of California. THE MINERALS OF BORON, CALIFORNIA. [By] Boron Bulletin Committee, Earl Pemberton, Editor: 40 p., illus., maps, Box 106, Montebello, California, 1960, 17 refs.

The deposit of massive, crystalline sodium borates at Boron, Kern County, western Mohave Desert, is the most important occurrence of borate minerals ever found in the western world. For nearly 30 years the district has supplied most of the borates in the world market, yet the known reserves of the deposit have scarcely been tapped. Current production from a huge open pit is at the rate of over 1 million tons of crude sodium borate ore per year.

To the mineralogist the district is of interest not just because of its economic importance but because of the unusual nature of the deposit and the variety of minerals found here. The primary purpose of this bulletin is to discuss the origin of the deposit and describe the mineral occurrences.--From p. 3.

3-2335. Sørensen, Henning. BERYLLIUM MINERALS IN A PEGMATITE IN THE NEPHELINE SYENITES OF ILÍMAUSSAQ, SOUTH WEST GREENLAND (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 17. Minerals and Genesis of Pegmatites, p. 31-35, table, 1960) 8 refs.

In the Ilimaussaq complex 2 types of pegmatites may be distinguished: 1) conformable pegmatites of magmatic origin, 2) cross-cutting pegmatites rich in albite and/or analcime. The latter type of pegmatite is most probably of hydrothermal origin.

In a vein of albitite at Tugtup agtakôrfia 2 Be-bearing minerals have been found; the one resembles the chkalovite of the Kola peninsula, the other has provisionally been termed "beryllium sodalite."

The distribution of Be in the rocks and minerals in Tugtup agtakôrfia was examined spectrographically. All minerals and rocks were found to be very poor in Be.--Auth.

3-2336. Karpoff, Boris S. HOLMQUISTITE OCCURRENCES IN THE MINING PROPERTY OF QUEBEC LITHIUM CORPORATION, BARRAUTE (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 17. Minerals and Genesis of Pegmatites, p. 7-14, 5 figs., 2 tables, 1960) 5 refs.

A mineralogical examination of some samples from the Li-rich pegmatites of Lacorne area, Quebec, have contributed to the identification of one mineral as "holmquistite."

It occurs mostly in contact zones between pegmatite dikes, poor in spodumene, granodiorite and hornblendite, as a metasomatic mineral in paragenesis with biotite and hornblende. Some very well formed crystals were observed.

A single crystal determination shows that the mineral is definitely orthorhombic, rather than monoclinic, and has the crystal structure characteristic of anthophyllite rather than glaucophane.

A complete chemical analysis is being carried out. Li content has been determined as 3.56% of Li_2O. The other oxides correspond very closely to the values given for the Swedish holmquistite. A complete X-ray result is given.--Auth.

3-2337. Milton, Charles, and others. SILICATE MINERALOGY OF THE GREEN RIVER FORMATION OF WYOMING, UTAH, AND COLORADO (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 21. Other Subjects, p. 171-184, 13 figs., 2 tables, 1960) 33 refs.

The Eocene lacustrine beds of the Green River formation represent a long epoch -- hundreds of thousands, if not millions, of years -- of sedimentation of calcareous or dolomitic mudstones containing much organic matter, with interbedded tuffs, followed by a period of desiccation and evaporation in which vast deposits of trona in Wyoming and smaller ones of nahcolite in Utah and Colorado formed. These beds have not been intruded by igneous rocks or regionally metamorphosed; they contain notable quantities of hydrocarbons (often as inclusions in the silicate and other minerals), and fossils in them are unaltered; yet they contain authigenic minerals, found elsewhere in the world only in alkalic pegmatites or other magmatic environments, that are believed to have formed under very moderate pressures and low temperatures (probably under 200°C.). The 2 major groups of Green River minerals are silicates and carbonates, occurring in mudstones, bituminous shales, and massive carbonate beds. This paper reviews 11 well-defined authigenic Green River silicate species, also clay minerals, and quartz.

Silicate minerals of the Green River are: leucosphenite, labuntsovite, elpidite, sodic amphiboles (magnesioriebeckite), acmite, analcite, albite, searlesite, loughlinite, reedmergnerite, garrelsite, clay minerals, and quartz.--Auth.

3-2338. Whelan, James A. UNUSUAL SOLUTION(?) CAVITIES IN THE MANNING CANYON SHALE NEAR FAIRFIELD, UTAH: Geol. Soc. America, Bull., v. 72, no. 5, p. 767-768, fig., table, May 1961, 2 refs.

One bed of the Manning Canyon shale [Mississippian and Pennsylvanian] in Manning Canyon, Utah, contains numerous elongate cavities, rectangular in cross section, all oriented down dip. The cavities contain a small amount of residue consisting of fine-grained Fe-stained quartz. The solution of carbonate veins is postulated as the origin of the cavities.--Auth.

3-2339. Sidorenko, E. F. MINERALOGY OF CLAYS FROM THE ODESSA COAST OF THE BLACK SEA. Translated by Royer and Roger, Inc.: Internat. Geology Rev., v. 3, no. 4, p. 325-336, 4 illus., 6 graphs, 7 tables, Apr. 1961, 3 refs.

A study was made of the clay belonging to the upper Miocene (bluish-gray clay), upper Pliocene (reddish-brown clay), Holocene and Pleistocene loesslike clay) from the landslide district near Odessa. The investigation has shown that the clays of these 3 units are not monomineralic and that each one has features indicating the prevalence of hydromica or montmorillonite as the main rock-forming mineral. Thus, hydromica is dominant in the blue-gray clay, while montmorillonite prevails in those that are reddish-brown and loesslike. These deductions have been fully confirmed by calculation of the size of the basic cells.--Auth.

3-2340. Connally, G. Gordon. HEAVY MINERALS IN THE GLACIAL DRIFT OF WESTERN NEW YORK: Rochester Acad. Sci., Proc., v. 10, no. 5, p. 241-278, 10 pl., 7 tables, June 1960, 33 refs.

The Albion-Rochester, Waterloo-Auburn, Hamburg-Batavia-Victor, and Valley Heads moraines, the Binghamton drift, and the Illinoian till have a common provenance which is illustrated by the dominance of purple garnet over red garnet. The source of the ice that deposited these sediments was NE. of Lake Ontario.

The provenance of the Olean drift is different from that above as illustrated by a distinctive garnet ratio, sorting coefficient, and the composition of the light fraction. The source of the ice that deposited this sediment may be S. of (or in) the Adirondack mountains as proposed by Dreimanis.

The morainal deposits in western New York increase in age from N. to S. Accompanying this age increase is an increasing alteration of hypersthene and monoclinic pyroxene which is manifested in the appearance of the grains. There is also a decrease in the relative amount of the unstable minerals from N. to S. From the above observations it is concluded that a lack of stability is demonstrated by hypersthene, monoclinic pyroxene; and hornblende, with respect to the age of the deposit in which they occur.

The instability of the minerals can best be represented by stability ratios. These ratios are computed by dividing the amount of unstable mineral by the amount of stable mineral (garnet in this study).

From the stability curves, dates may be obtained, beyond which the unstable minerals should cease to persist in similar deposits. These dates are 25,400 years for monoclinic pyroxene, 36,500 years for hypersthene, and 120,000 years for hornblende. The order of persistence observed in this study (garnet, hornblende, hypersthene, monoclinic pyroxene) is consistent with that noted by Pettijohn.

From the stability curves, the dates for the deposition of the Albion-Rochester and Hamburg-Batavia-Victor moraines may be obtained. These dates are between 8,000 and 8,500 years and between 10,000 and 10,300 years respectively.

The stability ratios remain constant throughout most of the length of the Valley Heads moraine and may be used to define this moraine. The results from the Valley Heads moraine suggest that stability ratios may be used to define all the moraines in New York state.--Auth. concl.

9. IGNEOUS AND METAMORPHIC PETROLOGY

See also: Areal and Regional Geology 3-2157, 3-2158; Structural Geology 3-2203, 3-2205; Stratigraphy 3-2255, 3-2256; Mineral Deposits 3-2410, 3-2422.

3-2341. Robertson, Forbes. A FIELD CLASSIFICATION OF APHANITIC IGNEOUS ROCKS FOR THE STUDENT: Jour. Geol. Education, v. 9, no. 1, p. 35-38, table, Spring 1961.

A systematic scheme is offered for the classification of aphanitic igneous rocks, based chiefly on hand-lens identification of the phenocrysts. Secondary emphasis is placed on certain physical characteristics of the rocks, including color, luster, and the nature of cavities. The scheme is intended to provide a reasonable first approximation of rock identity in the field.--Auth.

3-2342. Ault, Wayne U., and others. LAVA TEMPERATURES IN THE 1959 KILAUEA ERUPTION AND COOLING LAKE: Geol. Soc. America, Bull., v. 72, no. 5, p. 791-794, 2 figs., table, May 1961, 3 refs.

The 1959 summit eruption of Kilauea Volcano, Hawaii, filled the crater of Kilauea Iki with a lake of lava 365 ft. deep. Temperatures of the erupting basalt ranged between 1,060° and 1,190°C. Temperatures down a 12.7-ft.-deep hole, drilled into the crust of the lake 5 months after cessation of eruptive activity, agree with calculated temperatures based on the heat equation. The cooling effect of rainfall is pronounced only in the upper 3 1/2 ft. of the crust.--Auth.

3-2343. Tilley, C.E. DIFFERENTIATION OF HAWAIIAN BASALTS; SOME VARIANTS IN LAVA SUITES OF DATED KILAUEAN ERUPTIONS: Jour. Petrology, Oxford, v. 1, no. 1, p. 47-55, illus., Feb. 1960.

The paper discusses briefly the trend of fractionation exhibited by basaltic lavas of 3 dated Kilauea eruptions, the suite of 1921 in Kilauea caldera and the suite of the 1840 and 1955 flank eruptions of Kilauea in the E. rift zone. The trend revealed is graphically indicated in terms of Fe/Mg and alkali enrichment.--Auth.

3-2344. Parsons, Willard H. ORIGIN OF TERTIARY VOLCANIC BRECCIAS, WYOMING (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 13. Petrographic Provinces, Igneous and Metamorphic Rocks, p. 139-146, 1960) 23 refs.

Middle Eocene pyroclastic rocks in the Absaroka Mountains and Yellowstone National Park have been divided into early acid breccias, early basic breccias, late acid breccias, and late basic breccias with early and late basalt sheets. Near intrusive centers, these pyroclastic rocks are volcanic breccias, tuff breccias, and agglomerates with a small percentage of interbedded tuffs and lava flows. Most of these breccias are heterolithologic, nonvesicular, very irregular in fragment size, lack sorting, and have very crude, if any, bedding. They were formed by the fragmentation of previously crystallized volcanic rocks. Such fragmentation apparently occurred in part during or before extrusion of the breccias from dozens of small vents. Most of the vents are filled with such heterolithologic breccias. A few miles from extrusive centers the pyroclastic rocks consist of coarse lahars, volcanic conglomerates, and volcanic sandstones.

The major breccia units have a surprisingly uniform continuity and thickness throughout the Absaroka region. Local angular unconformities are common within these major units, however. The unconformities represent the remnants of cone structures, caldera collapse areas, and original depositional overlap of pyroclastic beds from various volcanic centers.--Auth.

3-2345. Ljunggren, Pontus. A FORMATION OF MAREKANITE AT EL FISCAL, GUATEMALA: Geol. Mag., v. 97, no. 1, p. 49-52, illus., Jan.-Feb. 1960.

An outcrop of obsidian pebbles in a gray volcanic rock was investigated in the field and subsequently examined in the laboratory by means of optical,

X-ray, and D. T. A. methods. The results show that the gray rock arose from obsidian through a micro-cracking, causing a formation of marekanite balls (massive obsidian) surrounded by a very brittle gray rock (micro-cracked but completely unaltered volcanic glass).--Auth.

3-2346. Wager, L. R. THE MAJOR ELEMENT VARIATION OF THE LAYERED SERIES OF THE SKAERGAARD INTRUSION AND A RE-ESTIMATION OF THE AVERAGE COMPOSITION OF THE HIDDEN LAYERED SERIES AND OF THE SUCCESSIVE RESIDUAL MAGMAS: Jour. Petrology, Oxford, v. 1, no. 3, p. 364-398, illus., Oct. 1960.

Using variation diagrams for the major elements in the layered rocks, estimates are made of the average amounts of the various elements in the total rock separating at successive stages. From the analyses of the chilled marginal gabbro, taken to represent the composition of the initial magma, and with the further likely assumption that the Skaergaard intrusion [Greenland] is a closed system, at any rate for most of the elements, various hypotheses on the relative volumes of the different parts of the intrusion are tested to find the one best fitting the known distribution of the elements in the observable rocks. Estimates are then made of 1) the over-all composition of the hidden part of the intrusion by subtracting the amounts of an element in the observed rocks from the total in the initial magma, and 2) the composition of the successive residual magmas formed as a result of the crystal fractionation.--Auth.

3-2347. Drever, Harald I. IMMISCIBILITY IN THE PICRITIC INTRUSION AT IGDLORSSUIT, WEST GREENLAND (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 13. Petrographic Provinces, Igneous and Metamorphic Rocks, p. 47-58, 5 figs., 2 pls., table, 1960) 9 refs.

Description and interpretation of a globular structure, in a picritic minor intrusion, which is believed to be the most unambiguous natural evidence hitherto recorded of silicate immiscibility.--Auth.

3-2348. Hamilton, Warren B. SILICIC DIFFERENTIATES OF LOPOLITHS (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 13. Petrographic Provinces, Igneous and Metamorphic Rocks, p. 59-67, 2 figs., table, 1960) 12 refs.

A summary of the petrology, and particularly of the chemical composition, of the silicic differentiates of the Bushveld, Wichita, and Sudbury lopoliths, and of allied rocks in the region of the Duluth lopolith, illustrates the distinctive characteristics they share. Granophyres, allotriomorphic granites, and rhyolites are widespread. They are alkaline rocks, high in alkalis and total Fe, low in CaO and Al_2O_3.

These differentiates are strikingly unlike the silicic rocks of calc-alkaline provinces (basalt-andesite-rhyolite, and granodiorite-granite associations), and the genesis of the contrasting types is probably completely different.

Each lopolith is a stratigraphic unit, and at least the Bushveld, Sudbury, and probably Wichita complexes are overlain by extrusive rhyolites which share the distinctive compositions of the immediately underlying granophyres and granites. Daly's conclusion that the Bushveld lopolith was essentially extrusive can probably be applied correctly to these others also.--Auth.

3-2349. Toulmin, Priestley, III. COMPOSITION OF FELDSPARS AND CRYSTALLIZATION HISTORY OF THE GRANITE-SYENITE COMPLEX NEAR SALEM, ESSEX COUNTY, MASSACHUSETTS, U.S.A. (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 13. Petrographic Provinces, Igneous and Metamorphic Rocks, p. 275-286, 3 figs., 2 tables, 1960) 10 refs.

Compositions of $CaAl_2Si_2O_8$-poor microperthites from granites and syenites in this area, determined by an X-ray diffraction method on thermally homogenized material and by chemical analysis, are interpreted in light of recent experimental work in the system $KAlSi_3O_8$-$NaAlSi_3O_8$-SiO_2-H_2O to yield information on the crystallization history of the rocks. Massive syenite, syenitic dikes, and porphyritic microgranite are marginal to the Cape Ann pluton of microperthite granite. Microperthite phenocrysts of the porphyritic microgranite (Or_{56-61}, weight percent) are more potassic than feldspars of the granite (Or_{44-52}), in agreement with experimental crystallization paths and the interpretation of the porphyritic microgranite as a chilled border zone of the granite. Field evidence shows that the syenite represents one or more showers of feldspar crystals probably resulting from volcanic devolatilization of the granitic magma. Where the pluton had a gently dipping floor the feldspars accumulated to form syenite. The composition of the syenite feldspars (Or_{24-43}) reflect a shift in liquid-crystal equilibria such that the liquid, after devolatilization, crystallized feldspars more sodic than itself. This also agrees with the experimental work. Feldspars of syenite dikes (Or_{27-31}) coincide with the minimum in the system $KAlSi_3O_8$-$NaAlSi_3O_8$-H_2O, suggesting an origin by remelting of massive syenite.--Auth.

3-2350. Ernst, Wallace G. DIABASE-GRANOPHYRE RELATIONS IN THE ENDION SILL, DULUTH, MINNESOTA: Jour. Petrology, Oxford, v. 1, no. 3, p. 286-303, illus., incl. geol. map, Oct. 1960.

The gently dipping 1,500-ft. thick Endion sill intrudes Keweenawan flows at Duluth, Minnesota. In a general way, from the bottom to the top of the body, there is a gradual transition from diabase through intermediate rock (granodiorite) to granophyre (adamellite). These latter 2 rock types together constitute about 40% of the exposed mass. Fractional crystallization of basaltic magma produced a great thickness of basic and intermediate rock types, which accumulated predominantly in the lower portions of the sill and probably in the end-stage production of an aqueous, salic, alkalic liquid. It is proposed that, due to initial inclination of the sill, part of this salic fraction migrated updip, accumulated and reacted with portions of the diabase and intermediate rock, and completed crystallization at the presently exposed level. Alternatively, much or all of the Endion sill granophyre may represent a separate intrusion unrelated to differentiation of the earlier diabase. In either case the sill is composite. Bulk compositions of cryptoperthites indicate both granophyre and intermediate rock crystallized at magmatic temperatures.

Compositional uniformity of the clinopyroxene and lack of Fe enrichment in felsic portions of the Endion sill may be the result of accumulation of H_2O and the presumed maintenance of nearly constant partial O pressure during crystallization. This mechanism would furthermore account for inferred late magmatic solid solution between alkali feldspar and $KFe^{3+}Si_3O_8$,

with subsequent subsolidus exsolution of hematite.--Auth.

3-2351. Taylor, H. P., Jr., and James A. Noble. ORIGIN OF THE ULTRAMAFIC COMPLEXES IN SOUTHEASTERN ALASKA (In: International Geological Congress. 21st, Copenhagen, 1960. Report Pt. 13. Petrographic Provinces, Igneous and Metamorphic Rocks, p. 175-187, 2 figs., 1960) 9 refs.

Thirty-five ultramafic bodies with associated gabbros are exposed along a linear belt 30 mi. wide and 400 mi. long in southeastern Alaska. These were intruded prior to emplacement of the Coast Range batholith, of Cretaceous age. Most are hornblende pyroxenites, but 8 of the larger complexes contain dunites and peridotites as well. Their many common features indicate that all were formed by a single mechanism.

When dunite is present, all the ultramafic rock types – dunite, peridotite, olivine-pyroxenite, pyroxenite, and hornblendite – are present in consistent zonal arrangement from the center outwards. An increase in Fe/Mg ratio of the minerals accompanies these changes. The complexes are all intrusive into gabbro, and petrologic features in all the bodies are similar and distinctive. Forsteritic olivine, diopsidic augite, hornblende, and magnetite are the only major minerals. No orthopyroxene occurs, and plagioclase (An_{90}) is found in only minor amounts in late-stage differentiates.

Ample evidence exists that there were magmas of the compositions of the several ultramafic rock types and that these were intruded in a consistent sequence. Differentiation by crystal fractionation is not an adequate mechanism for creation of these magmas. The preferred explanation is that they were derived by fractional fusion of ultramafic material in the mantle. --Auth.

3-2352. Noble, J. A., and H. P. Taylor, Jr. CORRELATION OF THE ULTRAMAFIC COMPLEXES OF SOUTH EASTERN ALASKA WITH THOSE OF OTHER PARTS OF NORTH AMERICA AND THE WORLD (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 13. Petrographic Provinces, Igneous and Metamorphic Rocks, p. 188-197, map, 1960) 26 refs.

A belt of ultramafic bodies with associated gabbros in southeastern Alaska [see abstract above] is part of a greater arcuate system that extends from western Alaska through the Canadian Yukon, southeastern Alaska, British Columbia, and perhaps into Washington, Oregon, and California. This greater system broadly comprises 2 parallel belts of ultramafic rocks and associated gabbros. Similarities to the occurrences of southeastern Alaska are so much greater than differences that it is reasonable to assume a common origin; namely, by fusion of ultramafic material in the mantle.

Zoned ultramafic complexes, though uncommon, have been described in a number of other places in the world. Probably not all have a common origin, but some, particularly those of the Ural Mountains, are so similar to those of southeastern Alaska as to call for the same origin. Many other belts of ultramafic rocks occur throughout the world, and it seems possible that zoning or other unusual relations will be found in these, to support or modify the proposed genetic theory.--Auth.

3-2353. Chesterman, Charles W. INTRUSIVE ULTRABASIC ROCKS AND THEIR METAMORPHIC RELATIONSHIPS AT LEECH LAKE MOUNTAIN, MENDOCINO COUNTY, CALIFORNIA (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 13. Petrographic Provinces, Igneous and Metamorphic Rocks, p. 208-215, 2 illus., 2 maps, 1960) 5 refs.

Actual intrusive contacts of ultrabasic rocks (serpentines) are exceedingly scarce in California. At Leech Lake Mountain, northern Mendocino County, California, serpentine sills show excellent intrusive contacts with tuffaceous graywackes of the Franciscan (Upper Jurassic to Lower Cretaceous) formation.

From detailed field and laboratory studies, it is concluded that: 1) the ultrabasic rock was intruded as a liquid magma, not as serpentine, 2) the intrusion imposed metamorphism on the graywackes and the grade of metamorphism is in the glaucophane schist facies with the formation of much jadeitic-pyroxene and scarce blue sodic-amphibole in silica-deficient tuffaceous graywackes, but without the formation of glaucophane, and 3) the intrusion was accompanied by a hydrothermal phase which effected partial serpentinization of the graywacke at the immediate contact and also formed a) veins composed of nephrite, jadeitic-pyroxene, hydrogrossular, and vesuvianite in the serpentine, and b) veinlets consisting of single minerals – pectolite, xonotlite, and calcite in the graywacke.

Emplacement of diabase sills between beds of chert preceded the emplacement of ultrabasic sills. Locally the diabase was intruded by peridotite and at the contact the peridotite was altered to nephrite and the diabase to a chlorite-serpentine-kaersutite-actinolite-pumpellyite rock. Later, hydrothermal alteration affected all of the diabase. The feldspar was altered in part to pumpellyite, the titaniferous augite to chlorite, pale-green actinolite, and blue amphibole (crossite), and the ilmenite and sphene to leucoxene.--Auth.

3-2354. Zies, Emanuel G., and Felix Chayes. PSEUDOLEUCITE IN A TINGUAITE FROM THE BEARPAW MOUNTAINS, MONTANA: Jour. Petrology, Oxford, v. 1, no. 1, p. 86-98, illus., Feb. 1960.

The article presents chemical analyses of the pseudoleucite and groundmass of a pseudoleucite tinguaite, chemical analyses of the principal minerals, chemical estimates of the mode of the groundmass, and both chemical and micrometric modes of the pseudoleucite. The principal minerals are hedenbergitic acmite, a nepheline containing 2.3% Fe_2O_3 and 7.9% K_2O, and K-feldspar containing a little BaO and very little Na_2O. The micrometric mode of the pseudoleucite, in satisfactory agreement with the chemical mode, is nepheline 29.8%, K-feldspar 66.2%, acmite 3.0%; the chemical mode of the groundmass is nepheline 26.8%, K-feldspar 46.6%, and acmite 26.7%. A new analysis of a nepheline from the Bancroft area, made to test the analytical procedure, is also included.--Auth.

3-2355. Harry, W. T., and C. H. Emeleus. MINERAL LAYERING IN SOME GRANITE INTRUSIONS OF S.W. GREENLAND. (In: International Geological Congress. 21st. Copenhagen, 1960. Report, Pt. 14. The Granite-Gneiss Problem, p. 172-181, 10 figs., 1960) 9 refs.

Unusual mineral banding occurs locally in some fluorite-bearing granites intruded into the Julianehaab granite and older schists and gneisses near

Ivigtut, SW. Greenland. There are 2 main occurrences, one near Tigssaluk fjord in the Frederikshaab district, the other in Alangorssuaq in the Julianehaab district.

In the Tigssaluk area, about 25 km. N. of Ivigtut, 2 biotite-granite stocks show exceptional concentrations of biotite, ore, sphene, and orthite in layers several centimeters or more thick and from 1 to over 100 m. long. These are best developed within 200 m. of the gneiss contacts, in the higher parts of the intrusions passing downwards without a break into normal unbanded granite. Most layers dip gently, some steeply, a few are contorted and accompanied by folds, faults, and some structures reminiscent of sedimentary slumping.

In Alangorssuaq, about 40 km. S. of Ivigtut, biotite-granite and a large hornblende-granite intrusion with rapakivi characteristics are associated with gabbro and syenite in a major plutonic igneous complex. Layering due to concentrations of dark minerals, though rare in the biotite-granite, is common in the western parts of the rapakivi, which often display thin slightly curved hornblende-rich, sometimes pyroxenic bands up to a few centimeters thick, extending for up to several meters. The mafic bases of some of the thicker layers contain abundant primary precipitate olivine with clinopyroxene. In most exposures the layering dips gently, but steep dips are more frequent than in the Tigssaluk occurrences and some layering is almost vertical.

In both the Tigssaluk and Alangorssuaq areas rhythmic repetition every few centimeters of thin parallel or subparallel mafic layers is common in large exposures. Asymmetrical layers with sharp lower edges but grading upwards into granite are seen. Some examples resemble trough banding. Those near Tigssaluk fjord show intense mafic layering with strong gravity stratification rhythmically repeated vertically for as much as 3 m. and wedging out laterally in a few meters. Large microcline crystals are aligned within and parallel to such banding in the porphyritic granite of that area, although preferred mineral orientation is absent from the nonbanded granite.

Megascopically visible preferred mineral orientation is usually absent from the Alangorssuaq granites, but the long axes of sporadic oval xenoliths lie parallel to contiguous mafic layers, though a few meters from the latter they have random orientation.

The mineral layering is considered to have originated during complex processes of magmatic crystal accumulation. The sedimentation structures indicate a granitic magma of unusual fluidity, a suggestion supported by the occurrence of fluorite in some abundance.--Auth.

3-2356. Fyfe, William S., and others. COUPLED REACTIONS IN METAMORPHISM: A CORRECTION: Geol. Soc. America, Bull., v. 72, no. 1, p. 169-170, diag., Jan. 1961, 4 refs.

The purpose of this note is to correct an earlier statement regarding the effect of coupled reactions upon the stability fields of metamorphic mineral assemblages; specifically, the statement [Geol. Soc. America, Mem. 73, p. 151-153, 1958] concerning the stability of the greenschist assemblage epidote-chlorite-quartz. It was suggested that the stability field of epidote, as determined from the system with epidote composition, could be extended by a coupled reaction involving chlorite, e.g., the reaction epidote + chlorite + quartz = pyroxene + anorthite + olivine + water. Clearly this cannot be the case: the stability field of any phase, as determined from the composition of that phase, must enclose the stability fields of all assemblages of which it is a member.--B. W. Pipkin.

3-2357. Nalivkina, E. B. METASOMATIC ZONALITY AND GENESIS OF SAPPHIRINE-BEARING ROCKS IN THE BUG REGION. Translated by Royer and Roger, Inc.: Internat. Geology Rev., v. 3, no. 4, p. 337-349, 9 figs, 7 tables, Apr. 1961, 12 refs.

Precambrian sapphirine-bearing rocks were discovered in the core of a borehole on the river Bug in the zone of the metasomatic changes of the pyroxene body. Their origin is a particular case of regional granitization and takes place in connection with the formation of charnockite. The area of modified pyroxenite, 1.7 m. thick in the core, has a symmetrical zonal structure and is subdivided into 6 subzones (in the direction to the center). 1) Pyroxenite, serpentinized, carbonatized pyroxenite (initial rocks); 2) Diopside-phlogopite-anorthite; 3) Corundum-anorthite phlogopite; 4) Sapphirine-corundum-microcline-biotite; 5) Corundum-sillimanite-sapphirine-microcline; 6) Sillimanite-sapphirine-corundum-prismatine-microcline. The minerals are not unstable together; some are replaced by others with a general tendency to form a microcline rock.--Auth. English summ.

3-2358. Riley, George C. PETROLOGY OF THE GNEISSES OF CUMBERLAND SOUND, BAFFIN ISLAND, NORTHWEST TERRITORIES: Canada, Geol. Survey, Bull. 61, 68 p., 2 maps (Map 1061A, scale 1:506,880, in pocket), 10 pls., 35 tables, 1960, 103 refs.

The petrology and petrography of the complex of Precambrian metamorphic and igneous rocks of Cumberland Sound have been investigated. Optical studies of over 400 samples were made, and chemical X-ray and spectrographic analyses were obtained.

The rocks are distributed into 5 orderly arranged metamorphic zones. Pyroxene-bearing, granitic-looking, predominantly massive rocks, classified as charnockites are believed to have been formed by plutonic metamorphism of rocks of high metamorphic facies. They exhibit the highest grade of metamorphism. Rocks in the second zone, called granulites, are divided into 5 varieties that are all produced by metamorphism under conditions of the granulite facies. Pyroxene-amphibole gneisses are intermediate in composition and metamorphic grade between the granulites and the amphibole-bearing rocks. Epidote-bearing rocks exhibit the lowest grade of metamorphism. Mineral assemblages in Al-rich layers were used to help to define the metamorphic facies of the rock groups in which they are found.

Differences in optical properties of potash feldspar, perthite, pyroxene-amphibole and Ti-bearing minerals were recognized in each zone and are related to changes in temperature and pressure. Charnockites probably formed at 650° to 750°C.; granulites at 600° to 675°C.; and pyroxene-amphibole rocks at 500° to 600°C. It is suggested that the type of potash feldspar and perthite is directly related to the grade of metamorphism. Amphibole and biotite are shown to be stable in charnockites and granulites, and cordierite is not considered alien to the granulite facies.--Auth.

3-2359. Olsen, Edward J. HIGH TEMPERATURE ACID ROCKS ASSOCIATED WITH SERPENTINITE IN

ASTERN QUEBEC: Am. Jour. Sci., v. 259, no. 5, . 329-347, 5 figs., pl., 2 tables, May 1961, 14 refs.

Highly serpentinized alpine-type peridotites frequently have small, relatively acid rock lenses associated with them. Weakly serpentinized or unserpentinized peridotites are usually associated with segregations of olivine gabbro. A study of the acid rocks found in the highly serpentinized peridotite at Asbestos in eastern Quebec indicates that they are metasomatically altered gabbro bodies. The initial alteration was to a biotite-saussurite which was further altered to a microcline-diopside-albite-quartz rock. The degree of alteration was dependent on structural attitude. These rocks represent high temperature alteration in the amphibolite facies which indicates that the serpentinization of the surrounding peridotite has taken place at a higher temperature than is represented by the general level of regional metamorphism, the epidote-amphibolite facies. Chemical evidence suggests that the components which were added to the gabbros may have been derived in part from the peridotite undergoing serpentinization.--Auth.

3-2360. Brownlow, Arthur H. VARIATION IN COMPOSITION OF BIOTITE AND ACTINOLITE FROM MONOMINERALIC CONTACT BANDS NEAR WESTFIELD, MASSACHUSETTS: Am. Jour. Sci., v. 259, no. 5, p. 353-370, 6 figs., 4 tables, May 1961, 18 refs.

Serpentine occurs near Westfield, Massachusetts, associated with amphibolite and impure marble in several thin lenses intercalated in steeply dipping pelitic schist. The schist and lens rocks are intimately intruded by quartz diorite. Where the quartz diorite has intruded serpentine or marble, thin monomineralic bands of biotite and actinolite have developed parallel to the contact, with the biotite band next to the intrusive.

Twelve biotite and 7 actinolite samples from one area of the monomineralic banding have been analyzed in duplicate by rapid analysis methods. The standards G-1, W-1, and Haplogranite were analyzed at the same time and under the same conditions. The ranges of variation of the major element concentrations in the biotites are SiO_2: 37.93-42.05%; Al_2O_3: 14.26-19.22%; FeO: 2.90-7.96%; Fe_2O_3: 1.13-3.04%; MgO: 17.98-24.42%; and K_2O: 8.96-10.31%. In the actinolites the ranges are SiO_2: 51.33-58.34%; Al_2O_3: .02-7.70%; FeO: 2.28-3.90%; Fe_2O_3: .56-1.74%; MgO: 19.49-24.90%; and CaO: 10.04-13.34%.

Results from analyses of biotite-actinolite pairs taken at varying distances from the contact between the 2 bands indicate culminations and depressions perpendicular to the contact in the content of the various elements of the 2 minerals. The variations in the Mg/(Mg + Fe) ratios in the 2 minerals indicate a degree of chemical disequilibrium in the bands, as it can be shown that attainment of equilibrium requires that the Mg/(Mg + Fe) ratios in different samples of the same mineral be similar.--Auth.

3-2361. Zen, E-an. PETROLOGY OF LOWER PALEOZOIC ROCKS FROM THE SLATE BELT OF WESTERN VERMONT (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 13 Petrographic Provinces, Igneous and Metamorphic Rocks, p. 362-371, 4 figs., 1960) 18 refs.

Rocks from the slate belt of western Vermont were studied by X-ray and microscopic techniques. Important mineral assemblages follow; they also all contain quartz, muscovite, and rutile: chlorite, chlorite-magnetite, chlorite-hematite, chlorite albite, chlorite-potassic feldspar, chlorite-albite-stilpnomelane, chlorite-albite-microcline-stilpnomelane, chlorite-paragonite, chlorite-chloritoid, chlorite-chloritoid-paragonite, and chlorite-chloritoid-epidote-hematite-magnetite.

In the field, stilpnomelane-bearing rocks and chloritoid-bearing rocks are intimately associated. Bulk composition, not physical environment of metamorphism, determined which mineral is stable. This conclusion concurs with the association of paragonite with chloritoid, and of stilpnomelane with microcline which is incompatible with paragonite. The stilpnomelane-microcline association also explains the absence of the biotite-chlorite pair, although biotite does occur in isolated samples.

Both stilpnomelane and chloritoid occur in rocks of very low metamorphic grade. Stilpnomelane is found in virtually unmetamorphosed graywackes.

The red, purple, and green colors of slates are due to the relative proportions of chlorite and hematite. Rims of green slate occur between purple and black slates, and between purple slate and limestone. Together with the obedience of the Phase Rule by the observed mineral assemblages, they indicate at least approach toward chemical equilibrium in these rocks.--Auth.

3-2362. Phemister, T. C. THE NATURE OF THE CONTACT BETWEEN THE GRENVILLE AND TEMISKAMING SUB-PROVINCES IN THE SUDBURY DISTRICT OF ONTARIO, CANADA (In: International Geological Congress, 21st, Copenhagen, 1960. Report, Pt. 14. The Granite-Gneiss Problem, p. 108-119, 2 figs., 1960) 4 refs.

In the southern part of the Canadian Shield it has been recognized that there is a sharp boundary between crystalline rocks on the S. forming the Grenville geological province and less metamorphosed strata to the N., the Temiskaming province. This boundary stretches from Lake Huron on the W. towards Labrador on the E., a distance of at least 500 mi. The present paper deals with a small but critical sector of this boundary in Ontario. Here at one part the passage from relatively unmetamorphosed quartzite on the N. with its diabase intrusions into the plastically deformed schists, amphibolites, and injected granitic gneisses of the Grenville is continuous and without any major break. The transition is a metamorphic one and takes place within a distance of not more than a hundred yards. Followed to the SW., however, there is interposed between the unaltered quartzite and the schist-gneiss complex an everwidening band of irregular felspathization which is unaccompanied by the plastic deformation characteristic of the rocks to the S. These metamorphic and metasomatic boundaries are intersected obliquely by a great fault so that in the eastern part of the area the Temiskaming-Grenville boundary becomes a faulted one.--Auth.

3-2363. Eardley, A. J. IGNEOUS AND TECTONIC PROVINCES OF WESTERN UNITED STATES (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 13. Petrographic Provinces, Igneous and Metamorphic Rocks, p. 18-27, 3 maps, secs., 1960)

A map showing the igneous provinces of the western United States and a complementary classification of provinces have been prepared. The igneous provinces are related to the tectonic provinces by means

of another map. A third map shows the provinces of primary magma from which the surface variants came.

It is concluded that the structures of the deformed miogeosyncline and shelf have had little effect on the position, size, and composition of the intrusive and extrusive bodies. The eugeosyncline, on the other hand, as the master belt of orogeny, is closely related to the igneous activity, and the climactic batholithic magmas are believed generated by the melting of silicic roots. On the basis of seismology and surface geologic observations only negligible roots are believed to exist under the structures of the miogeosyncline and shelf, yet silicic magmas have been injected and extruded there in very large amounts. This igneous activity is explained by the rise of basalt from the mantle and its injection as giant sills under the sial, which lead to the melting and assimilation of basal parts of the sial.--Auth.

3-2364. Kupfer, Donald H. PEGMATITE-GRANITE RELATIONSHIPS IN THE CALAMITY PEAK AREA, BLACK HILLS, SOUTH DAKOTA, U.S.A. (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 17. Minerals and Genesis of Pegmatites, p. 77-93, illus., maps, secs., 1960) 7 refs.

The Black Hills uplift of Paleozoic and Mesozoic rocks, N.-central United States, has a Precambrian schist core. Pegmatites occur in the schist surrounding a large granite unit. This granite unit is formed of numerous somewhat tabular granitic masses in schist. Each mass consists of alternate 3-in. thick layers of potash pegmatite and color-laminated, medium-grained, soda granite. The pegmatite-granite content of the area increases toward the center of the unit as schist screens decrease in size and number.

Two square miles around Calamity Peak, in the southwestern part of the granite unit, were mapped in detail. Schistosity is anticlinelike and steeply S.-plunging. Schistosity, granitic masses, and internal layering are generally concordant. The Calamity Peak mass, which is domal with a discordant core, has quaquaversal layering discordant to the schistosity in its northern half.

All transitional types, from pegmatite layers in granite to rare mineral pegmatites in schist, were observed. Therefore the layering is probably the key to pegmatite genesis. Variations of magmatic and granitization origins for the layering fail, however, to explain the observations, and further structural studies are needed. At present an injection-assimilation hypothesis is favored.--Auth.

3-2365. Hutchinson, R. M. PETROTECTONICS AND PETROCHEMISTRY OF LATE PRECAMBRIAN BATHOLITHS OF CENTRAL TEXAS AND THE NORTH END OF PIKES PEAK BATHOLITH, COLORADO (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 14. The Granite-Gneiss Problem, p. 95-107, 6 figs., table, 1960) 20 refs.

Petrotectonic studies of Enchanted Rock batholith, Llano County, Texas, and the N. end of Pikes Peak batholith show by the distribution and quantity of types of primary fracture systems that outer zone rocks have crystallized before inner zone rocks.

In Texas, narrow phacolithic sheets (Wolf Mountain phacolith, 917 m. y., Pb-alpha) and irregular-tabular bodies (Legion Creek mass, 893 m. y., Pb-alpha) are older than irregular-cylindrical intrusions (Enchanted Rock batholith, 815 m. y., Pb-alpha). Sheetlike and tabular masses could be earlier invasions preceding the main intrusive phase of cylindrical bodies. U and Th are concentrated in the younger granites.

Age of Pikes Peak batholith rocks is 1.08 to 1.05 billion years (K^{40}/A^{40}).

Oxide plots for rocks of the batholiths superposed on Tuttle's diagram indicate outer zone rocks crystallized from a liquid of granitic composition that produced a one-feldspar granite and inner zone rocks crystallized from a liquid that produced a 2-feldspar granite.--Auth.

3-2366. Stout, Martin L. DIABASIC AND GABBROIC INTRUSIONS IN THE FROST MOUNTAIN AREA, SOUTH-CENTRAL CASCADE MOUNTAINS, WASHINGTON: Am Jour. Sci., v. 259, no. 5, p. 348-352, 2 figs., May 1961, 9 refs.

Diabasic and gabbroic intrusions in the Frost Mountain area, approximately 70 mi. SE. of Seattle, represent at least in part feeders for 2 different sets of basalt flows. The older Naches basalt flows are probably Eocene in age, and the younger Yakima basalt flows are Mio-Pliocene. Field relations are of prime importance in distinguishing the 2 generations of intrusive bodies, but it is also generally possible to separate them by differences in degree of alteration.--Auth.

10. SEDIMENTARY PETROLOGY

See also: Stratigraphy 3-2218, 3-2228, 3-2229, 3-2231; 3-2250; Igneous and Metamorphic Petrology 3-2344; Engineering Geology 3-2466.

3-2367. Nelson, Bruce W. RECENT SEDIMENT STUDIES IN 1960: Mineral Industries Jour., v. 7, no. 4, p. 1-4, 6 illus., graph, Dec. 1960.

Recent sediment studies at Virginia Polytechnic Institute during 1960 were primarily concerned with trying to learn how sediment is transported from fresh-water streams into the open sea, a problem primarily of transportation and deposition in estuaries; and with trying to learn something of the fundamental make-up of the sediment itself by investigating the nature of mineral particles, chemical constituents, organic matter and pore fluids constituting the sediment complex. Measurements were concentrated in the York and Rappahannock estuaries. The point of maximum sediment concentration was found to occur where the salt content is very low, but not zero, suggesting that sediment is not necessarily precipitated when fresh water meets salt water. Core samples were taken of bottom sediments; their contents and pore waters were analysed. Salt content of the pore waters decreases with depth below the sediment surface. Analysis of the organic content is a part of the continuing program.--M. Russell.

3-2368. Flint, Richard Foster, and others. DIAMICTITE, A SUBSTITUTE TERM FOR SYMMICTITE: Geol. Soc. America, Bull., v. 71, no. 12, pt. 1,

p. 1809, Dec. 1960, 4 refs.

The authors propose the use of the terms diamictite, for poorly sorted terrigenous sedimentary rocks, and diamicton, for their nonlithified equivalents. These terms are substituted for symmictite and symmicton, previously suggested by the authors, as the latter terms were found to be preoccupied in the literature.--B. W. Pipkin.

3-2369. Judson, Sheldon, and Ronald E. Barks. MICROSTRIATIONS ON POLISHED PEBBLES: Am. Jour. Sci., v. 259, no. 5, p. 371-381, 3 pls., May 1961, 52 refs.

Very small striations, here called microstriations, occur on the smooth, polished surfaces of some pebbles. They average a millimeter or less long and are commonly less than 0.05 mm. wide.

Microstriations of random direction occur on artifically polished pebbles and also on pebbles from beach and fluviatile environments. Microstriations parallel to one another and oriented in sets occur on pebbles from various stratigraphic units including the Cloverly, Morrison, Wapiabi, and Windrow formations. These particular oriented microstriations are thought to be due to tectonic movement or compaction or both.--Auth.

3-2370. Greenwood, Robert. SEDIMENTARY BOUDINAGE IN CRETACEOUS LIMESTONES OF ZIMAPAN, MEXICO (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 18. Structure of the Earth's Crust and Deformation of Rocks, p. 389-398, 12 illus., map, 1960) 20 refs.

At Zimapan, Lower Cretaceous limestone and chert have been isoclinally folded. In thin-bedded strata above a massive reef-rock, partially lithified layers of pure limestone were drawn out into separate masses (boudins) of elliptical cross-section, while more fluid siliceous lime muds flowed around them without breaking. Boudinage is attributed to stretching of the partially lithified sediments, in the plane of bedding, during differential compaction above the reef-rock.

Deposition of chert around the boudins, preferentially at sites where low pressures prevailed during and after boudinage, fixes the time emplacement of chert as post-boudinage but pre-lithification. Chert is therefore termed diagenetic. While beds of originally siliceous limestone were chertified with retention of their microtextures, chertification in the purer limestones began as 0.3-1.0 mm. hollow spherules of microcrystalline quartz, which grew and coalesced to form a solid front.--Auth.

3-2371. Azmon, Emanuel. MARINE TO NONMARINE TRANSITION OF SEDIMENTS ACROSS LITTLE SYCAMORE BEACH, CALIFORNIA: Geol. Soc. America, Bull., v. 72, no. 5, p. 763-765, 2 figs., May 1961, 2 refs.

Grain-size distribution and mineral frequencies in Recent sediments reflect the longshore drift of sand which supplies Little Sycamore Beach with much more sand than does the canyon above it. The study also shows, as expected, marked differences between marine and nonmarine sediments.--Auth.

3-2372. McCrossan, Robert George. RESISTIVITY MAPPING AND PETROPHYSICAL STUDY OF UPPER DEVONIAN INTER-REEF CALCAREOUS SHALES OF CENTRAL ALBERTA, CANADA: Am. Assoc. Petroleum Geologists, Bull., v. 45, no. 4, p. 441-470, 18 figs., Apr. 1961, 60 refs.

The Woodbend group of Upper Devonian age in central Alberta is composed of a reef complex characterized by large-scale facies changes. The reefs, which grew in a subsiding basin, were initiated in restricted areas of suitable water depth. They are surrounded by the calcareous shales and argillaceous limestones of the Duvernay and Ireton formations. Correlation sections and isopach maps indicate a slightly greater subsidence on the eastern side of the basin during Duvernay deposition, after which the basin tilted so that the Ireton sea floor sloped gently W. Very fine carbonate clastics derived from the reefs were spread throughout the basin during Duvernay and lower Ireton time by a current probably flowing SE. The distribution of these carbonates was detected by mapping the average apparent resistivity of a stratigraphic interval. The basin reached its maximum depth when the calcareous shales of the middle Ireton were deposited. It then began to shallow and eventually the thinly interbedded coquinoid limestone and shale of the upper Ireton were laid down around and over the reefs.

Fine laminations indicate fairly quiet-water deposition of the Ireton and Duvernay sediments. Limestone nodules in these rocks are probably pull-apart structures.

The pore volume of these rocks decreases with increasing depth and carbonate content and resistivity increases correspondingly. The straight-line relation of carbonate content and porosity suggests that reduction of porosity is directly proportional to the volume of carbonate grains present. Other factors affecting porosity aside from carbonate content and depth are small by comparison. Internal redeposition of calcite has been unimportant.

Resistivity mapping in the subsurface shows promise of being a valuable exploration tool for determining the relative amount of coarser sedimentary grains in shale.--Auth.

3-2373. Chave, Keith E. CARBONATE SKELETONS TO LIMESTONES: PROBLEMS: New York Acad. Sci., Trans., v. 23, no. 1, p. 14-24, 3 figs., Nov. 1960, 15 refs.

Descriptive studies of modern carbonate skeletons and sediments do not provide data that can be used directly in the interpretation of ancient limestones. What is needed are studies of the processes involved. Some of the serious remaining gaps in our knowledge, which remain because products rather than processes have been studied are: 1) carbonate sedimentation (why and how fast?); 2) skeletal growth (how?); 3) carbonate mineral stabilization (how, where, and when?); 4) skeletal breakup (how, where, and what products?); 5) diagenesis of carbonates (how and where?); 6) primary structures (what and where?); and 7) fossilization (how and what?).

If students of modern carbonates will look carefully at the processes, our understanding of limestones and their historical significance will move rapidly ahead.--Auth. summ.

3-2374. Thomas, G. E., and Howard S. Rhodes. DEVONIAN LIMESTONE BANK-ATOLL RESERVOIRS OF THE SWAN HILLS AREA, ALBERTA: Alberta Soc. Petroleum Geologists, Jour., v. 9, no. 2, p. 29-38, 10 figs., table, Feb. 1961, 4 refs.

A case history of a textural and reservoir analysis

of transgressive, reef-fringed, limestone banks or platforms of the Upper Devonian Beaverhill Lake formation in the Swan Hills area of Alberta is presented to illustrate the relationships of grain, matrix and cement variants of carbonate rocks to porosity and permeability determinations. Successive rims of organic lattice, stromatoporoidal and algal, atoll-like "build-ups," with granular matrix, separate generally medium to dark brown pelleted lime muds containing abundant amphiporids, and intercalated lighter colored lagoonal carbonates, from open marine shales and nodular, argillaceous, crinoid- and brachiopod-rich limestones. The most effective reservoir material along the reef fronts or terraces consists of vuggy organic lattice, algal encrusted amphiporids (minor developments) and reworked stromatoporoidal, algal, and amphiporid material with intra-organic vugs, embedded in a porous, well-sorted, micro to finely granular or pellet matrix. Matrix grain size studies are essential to exploration and secondary recovery problems, as the granular material grades laterally into chalky or micrograined limestones which were laid down under lower energy conditions. Matrix granularity ratio outlines are considered to be superior to ecological maps (percentage of algal and stromatoporoidal material) in the prediction of shoal areas. Slice maps and textural studies are utilized to demonstrate transgressive shoals and progressive submergence of the bank atolls of this area.--Auth.

3-2375. Niino, Hiroshi, and K.O. Emery. SEDIMENTS OF SHALLOW PORTIONS OF EAST CHINA SEA AND SOUTH CHINA SEA: Geol. Soc. America, Bull., v. 72, no. 5, p. 731-762, 21 figs., 2 tables, May 1961, 42 refs.

Nearly 1,000 bottom samples from the shallow portions of the East China and South China seas were studied and compared with source areas and oceanographic conditions. Sediments of the gulf of Pohai and central Yellow Sea are fine-grained, low in calcium carbonate, and contain many unstable minerals and a moderately high percentage of organic matter. Most are contributed by the Hwangho (which carries much eroded loess), Yangtze, and many smaller rivers. The thickness of these sediments is so great as to constitute a modern zeugogeosyncline.

Sediments on the inner half of the continental shelf between Shanghai and Hainan and in the gulf of Tonkin are similar to those of the central Yellow Sea; they comprise modern detrital materials contributed to the continental shelf by many rivers, but in amounts as yet insufficient to cover the shelf everywhere.
Seaward of these sediments, on the outer half of the continental shelf between Korea and Hainan, is a broad belt of coarse sandy sediment from which finer sediments are winnowed away or prevented from being deposited by the strong Kuroshio Current. The sediment contains glauconite and much calcium carbonate in the form of foraminiferal tests and broken mollusk shells but very little organic matter. Because the inorganic portion is much coarser than that nearer shore, it is believed to constitute a littoral deposit left from a Pleistocene time of glacially lowered sea level. Locally on the shelf small areas of residual sediment near rock outcrops commonly contain reworked fossils. Pieces of pumice and many small shards of volcanic glass are present in the sediments, but nowhere are they abundant enough to form a dominantly volcanic sediment. The shelf sediments are similar in most respects to those on the continental shelf of California, and they clearly indicate deposition below present base levels of equilibrium.

Seaward of the continental shelf, in deep water of the continental slope, the sediments are finer-grained and contain more calcium carbonate. These sediments consist of the finer-grained terrigenous material that bypasses the shelf and is deposited so slowly in the quiet deep water that Foraminifera make up a large percentage of the total sediment.--Auth.

3-2376. Crary, A.P. MARINE-SEDIMENT THICKNESS IN THE EASTERN ROSS SEA AREA, ANTARCTICA: Geol. Soc. America, Bull., v. 72, no. 5, p. 787-790, 3 figs., table, May 1961, 8 refs.

Thickness of ocean sediments was obtained at 2 locations in the eastern Ross Sea area, Antarctica, during the International Geophysical Year. Sediment thickness in the vicinity of the Little America Station is about 1,325 m. Cores from the upper meter of these sediments are composed mainly of a mixture of coarse and fine glacial till.--Auth.

11. GEOHYDROLOGY

See also: Geomorphology 3-2179.

3-2377. Conover, Clyde S. GROUND-WATER RESOURCES - DEVELOPMENT AND MANAGEMENT: U.S. Geol. Survey, Circ. 442, 7 p., 1961.

An address presented to the Ground-water Section of the Western Resources Conference, Boulder, Colorado, Aug. 24, 1960. Discusses the need for appreciation and scientific evaluation of ground-water resources and for planned management of ground-water supplies in conjunction with surface water to meet the nation's growing demands for water.--U.S. Geol. Survey.

3-2378. Meyboom, Peter. A SEMANTIC REVIEW OF THE TERMINOLOGY OF GROUNDWATER MAPS: Internat. Assoc. Sci. Hydrology, Bull., v. 6, no. 1, p. 29-37, March 1961; also pub. as: Research Council Alberta, Contr. Ser. no. 139.

In this paper an attempt has been made to introduce some uniformity in the terminology to be used to designate various types of ground-water maps. Nine such maps have been described and terms referring to these maps are given in French, English and German.--Auth.

3-2379. Rao, Channapragada and Walter D. Rose. CAPILLARY PRESSURE AND SURFACE DISCONTINUITY IN POROUS MEDIA: Jour. Geophys. Research, v. 66, no. 4, p. 1199-1201, 3 figs., Apr. 1961, 3 refs.

A derivation of the capillary pressure term for viscous fluids at a fluid-fluid interface is given in the general form. Hall's paper is discussed in part, and it is emphasized that the surface of discontinuity between the fluids cannot be ignored in describing the dynamics of multiphase fluid flow through a porous medium.--Auth.

3-2380. Bear, Jacob. ON THE TENSOR FORM OF DISPERSION IN POROUS MEDIA: Jour. Geophys. Research, v. 66, no.4, p. 1185-1197, 10 figs., Apr. 1961, 8 refs.

The variance of the bivariate normal distribution, which approximately defines the concentration distribution resulting from a tracer point injection into a uniform field of flow in a porous medium, is a second-rank tensor. When a point injection is subjected to a sequence of uniform movements in various directions, the final concentration distribution can be obtained by a summation of the tensors corresponding to the various movements. The concentration distribution across a transition zone, which develops when an abrupt interface between 2 miscible fluids is subjected to a sequence of uniform movements, can be determined by integrating the result for a single point injection over the entire tracer region.

The property of isotropic porous media to disperse a tracer fluid is defined by the constant of dispersion which is shown to be a fourth-rank tensor. If the displacement is defined as a second-rank tensor, the variance of the distribution is obtained by the product of twice the constant of dispersion and this displacement tensor.--Auth.

3-2381. Meyboom, Peter. ESTIMATING GROUND-WATER RECHARGE FROM STREAM HYDROGRAPHS: Jour. Geophys. Research, v. 66, no. 4, p. 1203-1214, 9 figs., 3 tables, Apr. 1961, 15 refs.; also pub. as: Research Council of Alberta, Contr. 140.

It is possible to separate graphically the base flow on stream hydrographs by plotting the logarithm of the discharge against time. Total potential ground-water discharge (Q_{tp}) at the beginning of any given base-flow recession is $Q_{tp} = K_1K_2/2.3$, where K_1 = ground-water discharge at the beginning of the base-flow recession (t_o), in acre feet per day; K_2 = time increment corresponding to one log cycle change in Q, in days.

The difference between the actual amount of ground-water discharge at the end of the base-flow recession and the total potential ground-water discharge at the beginning of the same recession is called 'remaining potential ground-water discharge.' The difference between the total potential ground-water discharge at the beginning of any given base-flow recession and the remaining potential ground-water discharge at the end of the preceding base-flow recession is a measure of ground-water recharge. The method is illustrated by the computation of the ground-water balance of the Calgary area, Alberta, Canada.--Auth.

3-2382. Bennett, Gordon D., and Eugene P. Patten, Jr. BOREHOLE GEOPHYSICAL METHODS FOR ANALYZING SPECIFIC CAPACITY OF MULTIAQUIFER WELLS: U.S. Geol. Survey, Water-Supply Paper 1536-A, p. 1-25, 8 figs., 2 tables, 1960, 12 refs.; also pub. as: Pennsylvania Geol. Survey, Bull. W-12.

Conventional well-logging techniques, combined with measurements of flow velocity in the borehole, can provide information on the discharge-drawdown characteristics of the several aquifers penetrated by a well. The information is most conveniently presented in a graph showing aquifer discharges as functions of the water level in the well at a particular time.

To determine the discharge-drawdown characteristics, a well is pumped at a steady rate for a certain length of time. While the well is being pumped, measurements are made of drawdown and of the discharge rates of the individual aquifers within the well. Discharge rates and drawdowns are usually recorded as functions of time, and their values for any given time during the test are obtained by interpolation. The procedure is repeated for several different rates of total well discharge. The well may be allowed to recover after each step, or discharge may be changed from one rate to another, and changes in discharge and drawdown may be measured by extrapolation. The flow measurements within the well may be made by use of a subsurface flowmeter or by one of several techniques involving the injection of electrolytic or radioactive tracers.

The method was tested on a well in Mercer County, Pennsylvania, and provided much useful information on aquifer yields, "thieving," and hydrostatic heads of the individual zones.--Auth.

3-2383. Back, William. ORIGIN OF HYDROCHEMICAL FACIES OF GROUND WATER IN THE ATLANTIC COASTAL PLAIN (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 1. Geochemical Cycles, p. 87-95, 5 figs., 1960)

The application of the concept of facies to the chemical aspects of ground water shows that the kinds of ions in solution and their concentration result from chemical processes responding to the lithology and the hydrologic flow pattern of a particular region. The Atlantic Coastal Plain was selected as a field model in which to study the portion of the geochemical cycle of elements that is controlled by the circulation of ground water. Significant characteristics of hydrochemical facies can be illustrated by methods similar to those used in lithofacies studies – trilinear diagrams that show the types of facies present in any area or formation; panel diagrams that show the over-all facies distribution; and maps showing isopleths of chemical constituents within certain formations. Within the Coastal Plain sediments the Ca Mg facies occurs in areas of high head (areas of recharge); the Na facies occurs in downgradient areas of lower head. Mapping of these facies demonstrates that the outcrop area of Cretaceous and Eocene sediments in southern Maryland is the discharge area for ground water rather than a recharge area as is more normally the role of the outcrop of artesian aquifers. --Auth.

3-2384. Hendrickson, G. E., and R. A. Krieger. RELATIONSHIP OF CHEMICAL QUALITY OF WATER TO STREAM DISCHARGE IN KENTUCKY (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 1. Geochemical Cycles, p. 66-75, 6 figs., 1960) 5 refs.

The relationship of chemical quality of water to stream discharge provides one key to the general hydrology and geochemistry of a drainage basin. Although there is a general inverse relationship between concentration of dissolved solids and the quantity of water being discharged by the streams, this relationship is not a simple one. A time lag in the decline in concentration of dissolved solids with increasing stream discharge may indicate that much of the ground water in the basin is discharged by evapotranspiration. Soluble salts left in the soil by evaporating ground water are flushed out with the first runoff to reach the stream. An increase in

concentration of dissolved solids at early stages of a stream rise may indicate weathering of freshly exposed rocks such as those exposed by strip mining. The soluble products of weathering accumulate on the surface during dry periods and are flushed into the stream with the next heavy rain. In large basins the relative concentrations of different ions vary as increments of discharge from the different geologic formations drained by headwaters and tributaries reach the sampling point.--Auth.

3-2385. Halstead, E.C. GROUND-WATER RESOURCES OF SUMAS, CHILLIWHACK, AND KENT MUNICIPALITIES, BRITISH COLUMBIA: Canada, Geol. Survey, Paper 60-29, 37 p., Maps 39-1960, 40-1960, (in pocket), scale 1:63,360, 9 tables (1 in pocket), 1961, 8 refs.

Ground-water geology of an area between 49°-49°-15'N., 121°45'-122°15'W. The paper is divided into 3 chapters which include general geology as well as ground-water data. The ground-water geology is described for each township in the map-area. Records of respresentative wells and test holes are tabulated in the appendix.

Surface sources provide ample water for parts of the area, but ground water is utilized to supply most needs. Ground water in the area generally contains less than 100 p.p.m. hardness and is medium to soft. However, ground water obtained from the lacustrine deposits within Sumas Valley has an objectionable, high Fe content. Bedrock is a source of water for domestic supplies only in the mountainous areas where surface deposits are thin or lacking. The permeable flood-plain deposits bordering the Fraser River are a potential source of large volumes of water sufficient to meet all anticipated future needs.--S.E. Jenness.

3-2386. Halstead, E.C. GROUND-WATER RESOURCES OF THE BRANDON MAP-AREA, MANITOBA: Canada, Geol. Survey, Mem. 300, 67 p., 6 figs., 3 maps (in pocket), incl. Maps 1066A and 1067A, scale 1:253,440, 7 tables, 1960, 10 refs.

This report summarizes all pertinent information on the nature and occurrence of ground water in an area extending from the International Boundary to Portage la Prairie, between Brandon and Marden, comprising about 168 townships. Bedrock is exposed in eroded areas where the glacial deposits are thin. The bedrock ranges in age from the Paleocene Turtle Mountain formation in the SW. corner to the Jurassic Amaranth formation in the NE. corner of this area. The Turtle Mountain formation consists of fine-grained sand or sandstone and bands of shale. Red shales, sandstone, and white gypsum constitute the Jurassic Amaranth formation. The main surficial features consist of glacial, lake, and alluvium deposits. The ground water in the area is derived essentially from direct penetration into the ground from precipitation, or downward and lateral percolation of surface water from lakes, ponds, or streams. The principal aquifers are till, sand and gravel, sandstone, and shales. Till, although a commonly weak aquifer, may yield sufficient water for general household uses. The sand and gravel aquifers are by far the most productive. Chemically, the water is generally hard. Nitrates are normally in negligible amounts. K and Na are also present in relatively small quantities. In general, the temperatures taken from wells that are from 25 to 100 ft. deep will be that of the mean annual atmospheric temperature. Below 100 ft. temperatures increase roughly 1°F. for each 100 ft. An appendix contains logs and records of wells and holes of the area.--M. Stewart.

3-2387. Horn, William L., and others. NORTHEASTERN COUNTIES INVESTIGATION: California, Dept. Water Resources, Bull. no. 58, 188 p., 5 pls., 65 tables, June 1960.

A comprehensive inventory of the surface- and ground-water resources of 15 counties in the northeastern portion of California. Ground water is stored in 32 distinct ground water reservoirs. Surface area of these reservoirs ranges from a few square miles to 5,000 sq. mi. Ground water occurs in a large number of geologic formations within these reservoirs. Major Quaternary water-bearing deposits include unconsolidated alluvial fans, terraces and lake-bed sediments, heterogeneous glaciofluvial deposits, and fractured volcanic flow rocks. Many of the ground-water reservoirs are underlain by extensive deposits of partially compacted older water-bearing units of the Tertiary-Quaternary Tuscan, Tehama, Cache, Victor, and Laguna formations, and unnamed and undifferentiated Tertiary-Quaternary sediments. In limited areas ground water is available from the Mehrten and Tuscan formations of Tertiary age.

Details on the 32 ground-water reservoirs are presented in tabular form as to: name and size of reservoir; description of major water-bearing units; principal recharge areas; subsurface inflow and outflow; direction of ground-water movement; geologic structures affecting ground-water storage and movement; pressure areas; water level depths; withdrawal capacity of wells; ground-water storage capacity data; water quality; use of ground water; overdraft; and principal references.--R. C. Richter.

3-2388. McKillop, Donald H., and others. UPPER SANTA ANA RIVER DRAINAGE AREA, LAND AND WATER USE SURVEY, 1957: California, Dept. Water Resources, Bull. no. 71, 51 p., 8 pls., 12 tables, May 1960.

This report contains an inventory of land use and surface- and ground-water resources of the upper Santa Ana river drainage area in southern California. Ground water is stored in thick deposits of gravel, sand, silt and clay sediments of late Tertiary and Quaternary age. Extensive Quaternary faulting in these sediments has formed crushed and impermeable fault gouge zones. These impermeable zones create effective barriers to ground-water movement and subdivide the valleys into numerous separate ground-water basins. Deep penetration of rainfall and percolation of runoff from the surrounding mountains constitutes the primary replenishment to the basins.

Ground-water extractions have gradually increased since 1900. By 1945 ground-water overdraft in this area was approximately 22,000 acre-ft. Since 1945, increased cultural development has demanded increasing ground-water extractions.--R. C. Richter.

3-2389. Rollo, J. R. GROUND WATER IN LOUISIANA: Louisiana, Geol. Survey, Water Resources Bull. no. 1, 84 p., 3 maps (under separate cover), diag. (under seperate cover), 16 figs., 10 tables, Aug. 1960, 55 refs.

Fresh ground water is available in Louisiana in rocks which range in age from Paleocene to Recent. The Wilcox group of Paleocene and Eocene age con-

tains the oldest aquifers bearing fresh water in Louisiana. This group contains fresh water in northwestern Louisiana, where it crops out or is near the surface. Water-bearing sands in the Wilcox group generally are fine grained and lenticular, which preclude high yields from wells. The maximum recorded yield of a well in these deposits is about 500 g.p.m. (gallons per minute). Water from sands in the Wilcox generally is soft but commonly contains excessive amounts of iron. The Sparta sand of Eocene age yields fresh ground water to wells throughout much of northern Louisiana. Wells completed in this formation yield as much as 2,000 g.p.m. The water generally is soft but contains excessive amounts of Fe in some places. The Cockfield formation of Eocene age yields fresh ground water to wells in N.-central and northeastern Louisiana. Sands in this formation generally are finer grained and thinner than those of the aquifers in the Sparta sand; consequently, well yields are less. The largest recorded yield of a well in the Cockfield formation is about 700 g.p.m. The water generally is potable; however, in places highly colored water occurs in the upper part of the formation. Miocene deposits thicken wedgelike from central Louisiana and southern Mississippi toward the Gulf of Mexico and contain fresh ground water to a depth of as much as 3,550 ft. below the land surface. This represents the greatest known depth of fresh ground water in Louisiana. The water from Miocene deposits generally is soft and has a low Fe content. Pliocene sediments also thicken toward the Gulf of Mexico, and wells in southeastern Louisiana have flowed as much as 3,200 g.p.m. Pliocene deposits in southeastern Louisiana yield soft water with a low Fe content. The water generally is soft in southwestern Louisiana, but is slightly colored in some places and may have an excessive Fe content. Deposits of Quaternary age blanket much of Louisiana and in many places the deposits contain thick beds of sand and gravel. Quaternary deposits yield about two-thirds of the ground water pumped in Louisiana. Yields of wells commonly are very large, as much as 6,000 g.p.m. Water from these deposits generally is hard and contains excessive amounts of Fe, but high yields of wells and low water temperature make these sediments a valuable source of water for industrial cooling and irrigation.

In Louisiana the altitude of the base of occurrence of fresh ground water ranges from more than 200 ft. above sea level, in the northwestern part of the state, to about 3,500 ft. below sea level, in the southeastern part. The depth to which fresh water occurs decreases abruptly southward along a general E.-W. line, between 30° and 30 1/2° N. Along this line, which marks the southern limit of fresh-water flushing of Miocene and Pliocene deposits, the depth to which fresh water occurs may decrease by as much as 2,500 ft. in a distance of 5 mi.--Auth.

3-2390. Harder, Alfred H. WATER LEVELS AND WATER-LEVEL CONTOUR MAPS FOR SOUTHWESTERN LOUISIANA, 1958 AND 1959: Louisiana, Geol. Survey, Water Resources Pamph. no. 8, 27 p., 3 maps, 7 figs., 2 tables, Aug. 1960, 7 refs.

Of the 1,421,000 acres of rice grown in the United States in 1958, 28% or about 398,000 acres were harvested in southwestern Louisiana. Of this amount 202,000 acres (51%) were irrigated with ground water.

A total of about 650,000 acre-ft. of ground water was pumped from the Chicot aquifer in 1958; about 444,000 acre-ft. (2.2 acre-ft. per acre) was used to irrigate rice fields, 130,000 acre-ft. for industrial uses, 39,000 acre-ft. for municipal supplies, and 37,000 acre-ft. for rural uses. As a result of this withdrawal, the weighted-average water level declined 1 ft. in the period Apr. 1958-Apr. 1959. This decline is based on computations made using water-level contour maps constructed from levels measured in 207 wells screened in the Chicot aquifer.

The hydrographs for 24 of the 207 wells and a tabulation of the measured water levels indicate that water levels ranged from 121 ft. below land surface on Aug. 27, 1958, in well Cu-77 to 0.7 ft. above land surface on Apr. 22, 1959, in well SL-169, and that water levels have declined at rates ranging from 5 ft. per year in well Cu-445 to 0.0 ft. per year in well SL-171.--Auth.

3-2391. Cardwell, G. T., and J. R. Rollo. INTERIM REPORT ON GROUND-WATER CONDITIONS BETWEEN BATON ROUGE AND NEW ORLEANS, LOUISIANA: Louisiana, Geol. Survey, Water Resources Pamph. no. 9, 44 p., 6 figs., 3 pls., 4 tables, Aug. 1960, 15 refs.

This report summarizes data collected during the initial phase of the study of ground-water conditions along the Mississippi River between Baton Rouge and New Orleans. Only the area from just below Baton Rouge to Norco in St. Charles Parish is covered by this interim report; a reconnaissance report, U. S. Geol. Survey, Circ. 374, provides some information for the remainder of the project area. The final report will define the potential yield and quality of water in aquifers in the entire project area.

Physiographically, the area is the upper part of the deltaic plain of the Mississippi River. The Mississippi River changes from a gaining to a distributing stream in the upstream part of the area. The chief topographic features are natural levees and backswamps; however, in the extreme northeastern part of the area, older deltaic-plain deposits which have been uplifted and slightly tilted form a low upland.

The geologic history of the region has been dominated by the Mississippi River. Changing climatic conditions during the Pleistocene epoch resulted in deposition of a series of coarse- and fine-grained deposits (older deltaic deposits) that contain major aquifers in most of the area. In the latter part of the Pleistocene epoch during the recession of glaciers, coarse alluvial deposits of sand and gravel were laid down by the river along and W. of its present course N. of Donaldsonville. As deposition continued, the sediments became finer so that, except for sandy point-bar deposits along the river channel, the most recent deposits of the river are chiefly silt and clay.

All ground water is confined under artesian head by surficial fine-grained deposits, but the river has cut away these deposits along its present channel and is in hydraulic connection with the adjacent shallow sands. In the upstream part of the area, ground water moves toward the river except during high stages. In the downstream part, the river recharges the aquifers, and ground water moves away from the river almost continuously. Recharge may occur in local natural levee areas upriver; however, to the N. and NE. underflow from the older deltaic deposits probably accounts for a major increment.

The occurrence of fresh ground water is irregular and is affected by many factors - stratigraphy, youth of the deposits, earth structures, and recharge and discharge. The general availability of fresh water is shown by a preliminary map showing contour lines drawn on the base of fresh water as interpreted from

electrical logs. In much of the area fresh water occurs to depths of 300 to 500 ft., and locally to 700 ft. or more. However, in other parts of the area, shallow and intermediate sands contain saline water, and a few small areas have virtually no fresh ground water. Geologic sections show that there are 2 general water-bearing zones, or units, which comprise the principal aquifers. In addition, the shallow point-bar deposits, though generally of limited geographic extent, locally are a potential source of water.

Moderate to large quantities of water can be developed in most of the area. Specific capacities of large-diameter wells range from about 10 to about 100 g.p.m. (gallons per minute) per foot of drawdown, and yields exceeding 2,000 g.p.m. have been reported. The thick alluvial sequence of sand and gravel along and W. of the river between Plaquemine and Donaldsonville is capable of sustaining large yields. Specific capacities of wells tapping the older deltaic deposits generally range between 10 and 20 in Ascension Parish and from 20 to 70 at Norco in the southeastern part of the report area.

Water levels are relatively high except in the Laplace-Norco area where large withdrawals have lowered water levels. The shallow sands are hydraulically connected with the river, and water levels fluctuate with it. The effect of the river on water levels in the deeper sands is small and is due to the change in load on the aquifer caused by changes in river stage.

Ground water differs greatly in chemical character, but most is of the bicarbonate type. Water in shallow deposits is generally hard and contains relatively large amounts of Fe; water in deeper sands of the older deltaic deposits generally is soft and the concentration of Fe is less than 1 p.p.m. (part per million). Ground-water temperatures range from about 67° to about 75°F.; there is generally a gradual increase in temperature with depth. Other than excessive Fe and hardness, local occurrence of water high in chloride concentration is the principal water-quality problem. Where saline water occurs in the downdip or basal part of an aquifer, careful development is necessary to minimize salt-water encroachment.--Auth.

3-2392. Livesay, E. Boyd. DEVELOPMENT OF GROUND-WATER SUPPLIES FOR THE BRUNSWICK AND TOPSHAM WATER DISTRICT: New England Water Works Assoc., Jour., v. 74, no. 2, p. 89-112, 5 figs., table, June 1960.

The rapid expansion of U.S. Government military facilities at Brunswick and Topsham, Maine, resulted in a major increase in population and water consumption and required prompt construction of new water supply facilities by the water district.

Renovations and improvements to the existing well field at Jordan Avenue increased the dependable yield from 1.0 to 1.5 m.g.d., and showed clearly that keeping wells and suction system in clean condition pays dividends in increased pumping capacity, decreased pumping costs, and improved water quality.

The value of well conceived, carefully conducted, long-term pumping tests, when conditions call for such tests, has been well demonstrated during the district's water supply expansion program. Such tests enabled the district to "weed out" a poor producer (Durham Road well) from the initial program and to obtain reliable information on yield and water quality of the 2 new supplies developed (Williams Farm and Taylor Farm supplies.)

Long-term pumping tests at the Taylor Farm and Holden Farm sites on opposite sides of the Androscoggin River confirmed that infiltration of river water containing dissolved organic matter would cause taste and odor problems. Field experiments during the pumping tests and subsequent operating experience at the completed Taylor Farm works revealed that the taste and odor problem may be controlled by chlorination.

The district has increased the estimated safe yield of its ground-water supplies from 1 m.g.d. to 4 m.g.d., and has a potential of several m.g.d. additional at the Holden Farm site for possible future development. The total cost of the improvements to the Jordan Avenue supply, the new Williams Farm supply, and the new Taylor Farm supply was $548,164.--Auth. summ.

3-2393. Sterling, Clarence I., Jr. GROUND-WATER RESOURCES IN THE MATTAPOISETT RIVER VALLEY: New England Water Works Assoc., Jour., v. 75, no. 1, p. 9-15, 2 maps (1 on separate sheet, scale 1:24,000), graph, March 1961.

Surface and ground-water yields are interrelated in the Mattapoisett River valley, Massachusetts, so that the basin acts as a single unit insofar as water resources are concerned. About 5 1/2 million gallons per day of underground water can be taken from this drainage area with proper development to allow for dry periods. An integrated plan for developing new sources is needed to insure maximum development without interference of present supply.--M. Russell.

3-2394. Kimrey, Joel O. GROUND-WATER SUPPLY FOR THE DARE BEACHES SANITARY DISTRICT: North Carolina, Div. Ground Water, Rept. Inv. no. 3, 20 p., 4 figs., map, scale 1 in. to 3/4 mi. (in pocket), 2 tables, 1961, ref.

The test-drilling and water-sampling program indicates that the only fresh ground water in the area occurs in those deposits that lie in a zone whose base is about 100 ft. below mean sea level. These deposits may be divided into a lower aquifer and an upper aquifer. The lower or silty-sand aquifer underlies the entire area. The upper aquifer is composed of a clean-sand unit which is present throughout the entire area and a beach-gravel unit that is interfingered with the clean sand adjacent to the ocean. The upper aquifer has an average combined thickness of 45 to 50 ft.

The water in the lower aquifer is salty at some places. The salinity of water in this aquifer apparently is inversely proportional to the permeability of the material in which it occurs. The upper aquifer contains fresh water except at some locations adjacent to the ocean or sound.

The available geologic and hydrologic data indicate that at least 650 g.p.m. may be safely withdrawn by a shallow-well supply system from the upper aquifer near the center of the island. A long-term pumping test conducted during the summer months when ground-water usage and evapotranspiration loss are at a maximum, would permit refinement of this safe-yield estimate.

It is considered that the advantages offered by the use of infiltration galleries placed around the shorelines of the fresh-water lakes would justify their consideration as an alternate to a shallow-well supply system.--Auth. concl.

3-2395. LeGrand, Harry E. GEOLOGY AND GROUND-WATER RESOURCES OF WILMINGTON-

NEW BERN AREA: North Carolina, Div. Ground Water, Ground-Water Bull. no. 1, 80 p., 21 figs., 2 tables, 1960, 23 refs.

This report describes the geology and groundwater resources of an area of 3,988 sq. mi. in southeastern North Carolina, including Carteret, Craven, Duplin, Jones, Lenoir, New Hanover, Onslow, and Pender counties. The area is a relatively flat, sandy plain, the only steep slopes being in the vicinity of stream valleys. The climate is humid, the average annual precipitation being about 50 in.

This area is underlain by nearly flat-lying sedimentary strata, ranging in age from Cretaceous to Recent. Most of these strata are not consolidated. They dip very gently to the SE., in most places at a slope only slightly greater than that of the land surface, which is also to the SE. In aggregate the beds may be considered as an immense wedge, whose thin edge lies to the W. and whose thick part lies coastward. Except in parts of some stream valleys and in man-made excavations, outcrops of the older formations are rare. This is due to the flat topography and a thin veneer of sand and sandy clay of Pleistocene age. Interbedded sands and clays of Late Cretaceous age, consisting of the Black Creek and Peedee formations, are the near-surface strata in the western extremities of the area. Eastward these strata are overlain by calcareous deposits of Tertiary age. The Tertiary strata consist chiefly of the Castle Hayne limestone, although in Carteret County and in the eastern parts of Craven, Jones, and Onslow counties, the Yorktown formation overlies the Castle Hayne; collectively, they are considered in this report as the Tertiary limestone unit.

Three major aquifers furnish water to wells, at least 2 of them being available for use in any part of the area. They are 1) the sand beds of the Cretaceous formations, which contain fresh artesian water in approximately the western half of the area, 2) the Tertiary limestone unit which contains artesian water, and 3) the shallow surface sands throughout the area, which contain water within the reach of shallow drive point wells.

The current withdrawal of ground water is only a fraction of the available supply, and nowhere in the area has there been an overdraft of water from wells. Yields greater than 5 gallons a minute per foot of drawdown can be obtained from completely developed wells throughout the area. The majority of municipal and industrial wells are capable of yielding 1 million gallons of water per day.

Water in the surface sands is soft but corrosive. Water in the Tertiary limestone unit is not corrosive but is hard and in places contains objectionable quantities of Fe. The water in the uppermost Cretaceous beds is moderately hard, but water from several beds of sand in the Cretaceous formations is soft and contains no objectionable mineral matter for most industrial and municipal uses of the water. Except in western Lenoir and Duplin counties, aquifers containing salt water underlie the fresh-water aquifers, but the depth to the salt water is generally not accurately known. The presence of strata containing salt water and the possibility of contamination of the fresh-water aquifers are factors that may limit the quantity of ground water that can be withdrawn safely in some localities.--Auth.

3-2396. Leonard, Alvin R. GROUND WATER IN OKLAHOMA: 12 p., map, 2 secs., diag., 2 graphs, [Oklahoma City?], U.S. Geological Survey, 1960.

Ground water plays an important role in the economy of the state. It is estimated that about one-third of the water used in the state in 1956, or 400,000 acre-feet, came from ground-water sources. In 1957, 71% of the irrigation water used in the state came from underground sources, and ground water was used for irrigation in 57 of the state's 77 counties. More than 300 of the towns and cities of the state obtain all their municipal water supplies from ground water.

The major ground-water reservoirs, or aquifers, of Oklahoma may be classed in 4 general groups: 1) semiconsolidated sand and gravel underlying the High Plains; 2) unconsolidated alluvial deposits of sand and gravel along streams and adjacent to valleys; 3) sandstone aquifers; and 4) limestone aquifers, including, for the purpose of this generalized breakdown, dolomite and gypsum. The locations of these major aquifers are shown on a map. Areas on the map do not correspond exactly to outcrops, but are the areas where the formations contain significant quantities of potable water. Near their edges rock formations may be cut through by streams or they may be too thin to contain much water. On the other hand, some formations contain fresh ground water for many miles downdip from their outcrop areas, where wells must first penetrate overlying rocks to reach them.--From auth., p. 2.

3-2397. Hahn, Glenn W., and Jean A. Wosinski. GROUND-WATER LEVELS IN RHODE ISLAND, 1957: Rhode Island Water Resources Coordinating Board, Hydrol. Bull. no. 2, 32 p., 3 figs., 4 tables, 1960, refs.

Measurements of water levels in 35 wells in Rhode Island are given in this report. Levels in those wells reflecting natural ground-water recharge and discharge were consistently below average from Feb. to Dec., when recovery from the drought was rapid. Water levels in wells in areas of sizable withdrawals also were below average, in response to the drought and to greater-than-normal pumpage. By the end of the year, levels were approaching or were above average, indicating that the major ground-water reservoirs of the state were not adversely affected by the drought.--Auth.

3-2398. Lang, Solomon M., and others. HYDRAULIC CHARACTERISTICS OF GLACIAL OUTWASH IN RHODE ISLAND: Rhode Island Water Resources Coordinating Board, Hydrol. Bull. no. 3, 38 p., 20 figs., map (in pocket), table, 1960, 20 refs.

As indicated by the results of 21 pumping tests, the capacity of glacial outwash in Rhode Island to transmit, store, and yield ground water varies greatly from place to place and depends largely on the local lithologic character and hydrologic environment of the deposits. Coefficients of transmissibility, computed from driller's tests designed primarily to check well performance, range between 19,000 and 350,000 g.p.d. (gallons per day) per ft. and average about 130,000 g.p.d. per ft. Coefficients of permeability range from 820 to 5,800 g.p.d. per sq. ft. and average about 2,400 g.p.d. per sq. ft. Coefficients of storage range from 0.0008 to 0.20 indicating both artesian and water-table environments.

The average coefficients of transmissibility and permeability indicated by the tests are higher than average for outwash in Rhode Island as many of the existing wells were located at choice sites selected after somewhat extensive test drilling.

Water in most of the deeper-lying outwash in Rhode

Island although confined is hydraulically connected with water in the shallower permeable beds. The coefficient of storage of less than 0.001 indicates water under artesian pressure. But in a typical geologic environment in Rhode Island, such confinements usually are not extensive because of the discontinuity of beds of low permeability overlying the more permeable beds.--Auth.

3-2399. Thomas, Harold E., and M. T. Wilson. A CASE OF UNDERGROUND PIRACY (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 20. Applied Geology, p. 24-31, 1960) ref.

Navajo Lake is on a high plateau of southwestern Utah, and within Sevier River drainage basin. No surface outlet exists. Most subsurface water moves eastward toward Sevier River, but some moves southward to Cascade Spring in the Virgin River basin. At low and intermediate lake stages, Cascade Spring receives ± 40% of the outflow. However, this outlet can accommodate only 0.4 cu. m. per sec., and at highest recorded lake stages it received only +15% of the outflow. Only solutional enlargement of the conduit to Cascade Spring is needed to capture most if not all of the present outflow to Sevier River, but no measurable increase in conduit capacity has occurred during 5 years of study.

Geologic events pertinent to the present drainage pattern include: sedimentation (probably Eocene) which included extensive fresh-water limestones: volcanism (probably Oligocene) producing acidic flows and tuffs; uplift and slight eastward tilting of plateau; erosion of the volcanics and underlying sediments; establishment of underground drainage by limestone solution; basalt eruption (Pleistocene) forming dam and creating Navajo Lake; and, ever since plateau uplift, rapid erosion of its steep S. and W. edges which ultimately will cause surface piracy if underground diversion does not occur first.--Auth.

12. MINERAL DEPOSITS

See also: Geologic Maps 3-2123; Areal and Regional Geology 3-2145; Engineering Geology 3-2450.

3-2400. Agron, Sam L. MINERAL RESOURCES FOR THE GENERAL COLLEGE STUDENT: Jour. Geol. Education, v. 9, no. 1, p. 32-33, Spring 1961, 3 refs.

A course in mineral resources can be very popular with the general college student by providing a stimulating perspective on the essential role minerals have played and continue to play in the world. A consideration of the historical, political, and economic aspects of mineral resources is followed by a brief introduction to geologic principles and a study of the mineral fuels, metallic deposits, and selected nonmetallics. More geology departments should consider the advantages of offering such a course.--Auth.

3-2401. Herfindahl, Orris C. THREE STUDIES IN MINERALS ECONOMICS: 63 p., 12 graphs, Washington, D.C., Resources for the Future, Inc., 1961.

The first paper contains a discussion of the meaning of conservation. It does not focus on minerals especially but is cast in terms general enough for the ideas and analysis to be of interest to anyone concerned with conservation problems, no matter what his special field of interest. However, it does provide economic framework for the 2 following and specific papers, the first of which deals on a general level with the problem of long-run changes in the cost of producing mineral products. This problem is central to the whole debate over population growth and the adequacy of resources, and the outlook for the future. If, for example, energy supplies continue to be plentiful and cheap, as they have been for many decades, then not only can most of the metals be won from leaner ores, but also agricultural products, food and fiber, will be adequate through use of chemical fertilizers and machinery, the production or use of which requires large amounts of power and fuel.

The ideas in the real cost paper are basic and are directly useful in the analysis of many problems involving minerals. One of the situations discussed is that of shifts of the locations of mines as cost rises through time, with consequent shifts in the relative producing positions of different regions and countries. Changes of this type in the Pb and Zn industries over the last few decades and the resulting attempts to alter U.S. trade policy for minerals constitute the subject of the third paper.--From pref. by J.L. Fisher.

3-2402. Stewart, Harris B., Jr. MAN BEGINS TO EXPLORE 'INNER SPACE': New York Times, v. 110, no. 37,724, sec. 6, p. 52, 53, 80, 4 illus., May 7, 1961.

Emphasis on increased oceanographic research, indicated by the request for $97,000,000 in federal support for surveys and research, is justified because of the oceans' vast potential mineral and food resources and influence on climate. Only about 2% of the ocean bottom is adequately charted. Vast reserves of minerals exist in and beneath the oceans. Mg is already being recovered from sea water. Nodules of Mn, Ni, and Co cover some areas of the ocean floor; if the mechanism of their formation were known it might be possible to harvest these minerals much as salt is recovered from evaporation ponds.--M. Russell.

3-2403. Hawkes, Herbert E., and M. L. Salmon. TRACE ELEMENTS IN ORGANIC SOIL AS A GUIDE TO COPPER ORE (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 2. Geological Results of Applied Geochemistry and Geophysics, p. 38-43, 3 figs., 1960) 5 refs.

The location of ore beneath organic swamp soil is one of the principal prospecting problems in Canada. Results of recent investigations in Scandinavia suggest that many of the ore metals become relatively mobile under the reducing, acid environment of organic swamps. These observations were confirmed by results of experimental geochemical prospecting work at Captain Mines, Bathurst District, New Brunswick, Canada. Very well-defined dispersion patterns of Fe and Cu derived from a buried pyritic Cu deposit were mapped by analysis of swamp material. The patterns, as determined both in live moss and in dead organic matter, are displaced in the direction of movement of swamp water. Fe and Cu were determined by X-ray fluorescence analysis, a

method that has several practical advantages over wet chemical methods.--Auth.

3-2404. Warren, Harry V., and Robert E. Delavault. TRACE ELEMENT VARIATIONS IN RELATED ROCKS (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 2. Geological Results of Applied Geochemistry and Geophysics, p. 57-64, fig., 4 tables, 1960)

For some time geologists have been concerned with the so-called "normal" amounts of various trace elements present in large masses of apparently undifferentiated rocks. Geologists have been inclined to accept as a fact that almost every element could be found in every rock species, and that, in general, for every species there was a "normal" content from which there was not liable to be too great a deviation. Today it would appear more pertinent to turn to investigations which emphasize differences within the same species of rock inside one geographical area. Interpreting the significance of these variations in relation to segregations, migrations, and concentrations of various elements under conditions of metamorphism, provides a challenge to geologists.

Preliminary to a more complete investigation of trace elements in plutonic rocks from an area of southern British Columbia, the authors have concentrated on variations in the Zn and Cu content of these rocks, with particular reference to the presence, or absence, of mineralization.

The results obtained suggest that there do exist within the larger and more generally recognized geochemical provinces smaller but even better contrasting areas which may well represent the metamorphosed product of various facies of sedimentary rocks.--Auth.

3-2405. Wright, Harold D., and others. ROLE OF TRACE AMOUNTS OF URANIUM IN SOME BASE METAL SULFIDES FROM VEIN DEPOSITS (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 16. Genetic Problems of Ores, p. 248-260, 4 tables, 1960) 25 refs.

The amount and distribution of U has been studied in 270 samples of pyrite, sphalerite, and galena associated with uraninite in vein deposits of the western United States. The role of the U in the sulfides was investigated in detail in an effort to evaluate its relationship to the U content of the ore-forming solution. A test of Poisson distribution of alpha tracks in autoradiographs provided a means of establishing homogeneity of U distribution, indicative of incorporation during crystallization.

Although the U content ranged from one to several thousand parts per million, homogeneously distributed U is limited to samples with less than 80 p.p.m. Similar upper limits in all 3 minerals, together with experimental evidence cited, suggest that the homogeneously distributed U entered the minerals by adsorption during crystallization, rather than incorporation in the lattice.

Interpretation of trace elements in minerals has been seriously handicapped by a lack of means for establishing their role – whether included in foreign matter during crystallization, incorporated in the lattice or adsorbed during crystal growth, or introduced subsequently by replacement or by introduction along open spaces. The use of radioisotopes may be a powerful aid in experimental studies of trace elements and, in certain cases, in studies of natural minerals by radioactivation.--Auth.

3-2406. Dreimanis, Aleksis. GEOCHEMICAL PROSPECTING FOR Cu, Pb AND Zn IN GLACIATED AREAS, EASTERN CANADA (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 2. Geological Results of Applied Geochemistry and Geophysics, p. 7-19, 6 figs., table, 1960) 14 refs.

Geochemical and lithologic investigations of glacial deposits and their relationship to more than 10 ore bodies, containing Cu, Pb, and Zn sulfides in Quebec, Ontario, and New Brunswick have led to the following conclusions.

In most indicator trains of the above sulfides, detrital particles of ore minerals comprise less than 1% in till, with rapidly decreasing abundance down the ice flow direction. Therefore the geochemical anomalies are low (usually not exceeding 2-3 times the background values). Most of them are in vicinity of the ore body (10-1000 m.), with longer geochemical indicator trains (1-2 km.) at larger ore bodies.

Higher anomalies (4 to more than 10 times background values) result from upward migration or ground-water transport of soluble weathering products of ore minerals. The upward migration was found to be restricted to the basal portion of till: in noncalcareous till up to 1/2-2/3 m. above ore, in calcareous Zn up to 7 cm., Cu up to 3 cm. If the occurrence of ore is on slope with considerable ground-water movement, strong anomalies, particularly of Zn, develop downslope.

If geophysical anomalies, in areas covered by till, are tested for possible occurrences of Cu, Zn, or Pb ores, samples for geochemical analyses have to be taken at the base of till.--Auth.

3-2407. Neuerburg, George J., and Harry C. Granger. A GEOCHEMICAL TEST OF DIABASE AS AN ORE SOURCE FOR THE URANIUM DEPOSITS OF THE DRIPPING SPRING DISTRICT, ARIZONA: Neues Jahrbuch für Mineralogie, Abhandlungen, v. 94, p. 759-797, 16 figs. incl. illus., map, graphs, 8 tables, July 1960, 20 refs.

U deposits in a potassic siltstone horizon of the Precambrian Apache series were probably derived from spatially and temporally associated diabase intrusives. Differentiation of the diabase, involving extensive reactions with aqueous fluids, resulted in pyrogenic diabase, diabase pegmatite, K-enriched deuterically altered diabase, syenite, aplite, and deuteric veinlets. The deuteric veinlets are fillings left in contraction fractures by rest fluids as they drained from the intrusives. The distribution of U and Cu among the differentiates, despite changes due to weathering, is consistent with removal of most of the magmatic U and little of the magmatic Cu from the intrusives. The inferred amount of metal in the drained rest fluids is greatly in excess of the most optimistic estimates of ore reserves.--Auth.

3-2408. Kennedy, Vance D. GEOCHEMICAL STUDIES IN THE COEUR D'ALENE DISTRICT, SHOSHONE COUNTY, IDAHO. With a Section on Geology by S. Warren Hobbs: U.S. Geol. Survey, Bull. 1098-A, p. 1-55, 20 figs. incl. maps, graphs, 7 pls. (in pocket), 7 tables, 1960, 15 refs.

The Coeur d'Alene district has long been known for its production of Pb, Zn, Ag, and Cu. These metals, as mined, occur mostly in the minerals

galena, sphalerite, and tetrahedrite. The ore is in tabular shoots and pods along generally steeply dipping veins or mineralized faults which cut Precambrian rocks of the Belt series. Some of the veins, including ore shoots and intervening barren gangue filling, can be traced for thousands of feet along the strike and have been developed to depths over a mile below the surface. The soil cover over much of the area ranges from one to several feet in thickness, and has added to the difficulties of prospecting for new deposits.

This study was made to test the feasibility of using geochemical prospecting techniques in the search for ore in the Coeur d'Alene district. Semiquantitative chemical analyses were made principally for Cu, Pb, and Zn in soils collected near veins and in soils collected at a distance from known veins. In addition, some information was obtained regarding the use of soil analysis in prospecting for Sb and W veins. Samples of leaves, twigs, and fruits were analyzed both from plants growing in normal soils and from plants growing near ore deposits. A few water samples also were collected, and the pH and total heavy-metal concentrations were determined.

Evidence obtained from these studies indicates that analysis of soil for Pb, or for Pb and Zn, offers promise as a method of prospecting for new Pb-Zn ore bodies in this area. Prospecting for Cu by soil analysis may be feasible, but present data are not especially encouraging. Plants growing in mineralized areas contain abnormal amounts of the ore metals, but these anomalies are not so pronounced as those in the soil. The use of water analysis in the search for ore within the mining district is limited because of the contamination of surface waters by mine drainage.--Auth.

3-2409. Pollock, James P., and others. A GEOCHEMICAL ANOMALY ASSOCIATED WITH A GLACIALLY TRANSPORTED BOULDER TRAIN, MT. BOHEMIA, KEWEENAW COUNTY, MICHIGAN (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 2. Geological Results of Applied Geochemistry and Geophysics, p. 20-27, 2 figs., 1960) 8 refs.

Adjacent to an intrusion of syenodiorite, andesite-basalt flows cut by a fissure have been mineralized selectively in the top or amygdaloidal portion of the flow. Mineralization consists of disseminated chalcocite and bornite with minor amounts of other sulfides.

Late stage glaciation has deposited a thin mantle of till which covers the flows and much of the intrusive. Boulders of ore grade were found in the till. A geochemical study of the till successfully traced the fan of dispersed Cu-bearing till back to near the source, and self-potential studies pinpointed the outcrop.

The deposit is interesting in that the geochemical anomaly was formed in the till by material transported by the glacier. In a district which has been prospected for over a hundred years, a possibly economic deposit was found by modern prospecting methods close to excavations of early workers.--Auth.

3-2410. Carpenter, Robert H. A RESUME OF HYDROTHERMAL ALTERATION AND ORE DEPOSITION AT QUESTA, NEW MEXICO, U.S.A. (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 16. Genetic Problems of Ores, p. 79-86, 2 pls., 1960)

Hydrothermal alteration and molybdenite mineralization are closely associated at the Questa mine situated on the western slope of the Sangre de Cristo Mountains in Taos County, northern New Mexico.

The alteration occurs in extensive areas along an E.-W.-trending structural trench from the town of Questa eastward along the Red River Valley for 11 mi. Granite porphyry, porphyritic aplite and rhyolite porphyry have intruded Tertiary volcanics and Precambrian crystalline rocks which occur along the downfaulted zone. The areas of intense hydrothermal alteration are distributed in close association with these intrusives.

Molybdenite mineralization appears to have begun during a period of strong alteration, and continued after hydrothermal activity had largely ceased. Several stages of mineralization are evident.--Auth.

3-2411. Wayland, Russell G. TOFTY TIN BELT, MANLEY HOT SPRINGS DISTRICT, ALASKA: U.S. Geol. Survey, Bull. 1058-I, p. 363-414, 3 illus., 3 maps (2 in pocket), 4 tables, 1961, 10 refs.

Buried placer deposits in a belt about 8 mi. long by 1 mi. wide have yielded cassiterite as a byproduct to the recovery of placer Au. The deposits are at the base of unconsolidated gravels of early Quaternary age lying on an erosion surface of moderate relief cut on phyllite of Cretaceous age. The gravels are buried beneath 10 to 170 ft. of frozen muck and silt. The closest known outcrops of igneous rocks are a few small serpentinized mafic dikes about a mile N. of the belt, some monzonite masses about 4 mi. N. of the easternmost placer, and a biotite granite body about 6 mi. SE. Known lode mineralization exposed near the Sn belt consists chiefly of small, discontinuous quartz veins containing a few accessory minerals.

The Quaternary gravels consist largely of graywacke, phyllite, sandstone, light and dark quartzite, and quartz pebbles derived locally from the Cretaceous bedrock. The basal gravels which contain placer Au and cassiterite are well rounded and have more pebbles of quartz and light quartzite; they also contain a few cobbles and pebbles of granite and quartz-tourmaline rock. Nearly all cassiterite pebbles also contain brown tourmaline, as well as quartz and altered fragments of country rock. Chromite is common in part of the Sn belt. Many individual placer concentrations are related to details of the drainage system cut on the bedrock surface, particularly to minor gullies and terrace slopes. Nearly all cassiterite particles and most Au particles are well rounded and polished.

The writer considers the placer gravels to be derived from unexposed quartz veins immediately N. of the Sn belt which were brecciated and mineralized with tourmaline and cassiterite during a phase of Tertiary intrusive activity. Subsequent prolonged erosion by streams of moderately low gradient resulted in residual deposits. The mantle of Quaternary silt now conceals the roots of these lodes.

Total inferred reserves of cassiterite remaining in the buried placers are estimated to be about 2,000 tons. Recoverable reserves would depend on mining and recovery methods and economic conditions. Cassiterite would probably remain a byproduct to Au recovery. Sampling of tailings piles by the U.S. Geological Survey indicated an additional reserve of about 222 tons of cassiterite and $118,000 in Au.--Auth.

3-2412. Thomson, James E. URANIUM AND THORIUM DEPOSITS AT THE BASE OF THE HURONIAN

SYSTEM IN THE DISTRICT OF SUDBURY: Ontario, Dept. Mines, Geol. Rept. no. 1, 40 p., illus., 11 maps on 3 sheets (in pocket), 1960, refs.

Nineteen occurrences of radioactive conglomerate are described. These are similar lithologically to the uraniferous ores of the Blind River-Elliot Lake area and lie at the same stratigraphic horizon. Most of the deposits are greatly deformed. None are of sufficient size and grade to be mineable under 1958-1959 marketing conditions for radioactive minerals.

The deposits are distributed at irregular intervals over a distance of about 150 mi. at or near the base of the Huronian system from the Agnew Lake area to Lake Timagami. They lie with great angular and erosional unconformity upon a variety of pre-Huronian formations. The regional distribution of the radioactive conglomerates provides a valuable guide to the location and correlation of Huronian strata in those parts of the district that are complexly deformed. The data indicate that the original Huronian basin extended around the N. side of the Sudbury basin, but there is no indication of it on the S. side of the Sudbury structure.

Field and laboratory evidence show that the radioactive deposits are essentially of sedimentary origin; slight local regeneration of radioactive minerals occurred.--Auth.

3-2413. Noble, E. A. GENESIS OF URANIUM BELTS OF THE COLORADO PLATEAU (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 15. Genetic Problems of Uranium and Thorium Deposits, p. 26-39, 6 figs., table, 1960) 19 refs.

Most major U deposits of the Colorado Plateau are localized within restricted, elongate mineral belts. As no special features within the host rocks obviously account for the localization of ores, it is postulated that ore deposition was caused by some change within the mineralizing solutions.

It is further postulated that ore deposition resulted from decreasing pressure in laterally-moving, U-bearing ground water. The U is believed to have been derived from breakdown of uraniferous volcanic debris within the sedimentary rocks. Pressure resulting from compaction of the sediments and lateral compression would cause the ground water to move through aquifers. Decrease in pressure, away from the source, would decrease the solubility of the U and permit its precipitation. A mineral belt is thus delimited at one margin by a paleo-isobaric surface, marking the pressure at which precipitation could begin, and at the other margin by a roughly parallel surface marking the limit beyond which depleted solutions no longer formed major deposits.--Auth.

3-2414. Weir, Gordon W. and Willard P. Puffett. SIMILARITIES OF URANIUM-VANADIUM AND COPPER DEPOSITS IN THE LISBON VALLEY AREA, UTAH-COLORADO, U. S. A. (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 15. Genetic Problems of Uranium and Thorium Deposits, p. 133-148, 7 figs., table, 1960) 12 refs.

The geologic similarities of U-V and Cu deposits and the occurrence together of U, V, and Cu minerals in the Lisbon Valley area, a U-mining district on the Colorado Plateau, suggest that these deposits have a common origin.

The U-V deposits are in sedimentary rocks of Permian, Triassic, and Jurassic age. The Cu deposits are chiefly in sandstone of Cretaceous age but also are in older formations and in brecciated igneous rock of Tertiary age. The geologic habits of the deposits differ somewhat in each host rock but practically all the deposits are tabular bodies in virtually unaltered sandstone. Most U-V deposits are remote from faults, but the Cu deposits are generally found only in fractured rock near faults. The ore minerals impregnate sandstone and carbonaceous material; the Cu minerals also occur in small fractures. U and V minerals occur in a few Cu deposits, and Cu minerals occur in many U deposits.

The Cu ores were deposited from low-temperature hypogene solutions moving along faults in Tertiary time. The U-V ores were probably deposited from the same or similar solutions moving laterally through favorable beds.--Auth.

3-2415. Gross, G.A. IRON-FORMATIONS AND THE LABRADOR GEOSYNCLINE: Canada, Geol. Survey, Paper 60-30, 7 p., Map 34-1960 (in pocket), scale 1:1,013,760, 1961, 50 refs.

The distribution of Fe-formations in relation to regional geology is shown on the map for the area between the 51°-61°N. and 64°-72°W. General geological features of the Labrador geosyncline are outlined in the brief text accompanying the map. A succession of younger Precambrian rocks consisting of slate, argillite, dolomite, quartzite, and Fe-formation lie unconformably above older granite, granodiorite, and gneisses along the W. side of the belt of geosynclinal rocks. Along the E. side metamorphosed rocks of the geosyncline border a zone of gneisses, hypersthene granite, and amphibolites which are in part at least derived from geosynclinal rocks. Changes in regional structural trends are emphasized by the Fe-formation distribution in the southern part of the belt where a second stage of folding and deformation is evident. K-Ar age determinations are shown which corroborate the regional geological evidence. The succession of sedimentary rocks in which the Fe-formation occurs is present mainly in the western part of the belt and is thought to be contemporaneous with sedimentary, volcanic, and intrusive rocks of the eastern part.

Hematite-geothite ore deposits are present in Fe-formation in the central western part of the belt where rocks belong to the greenschist metamorphic facies. Fe-formations in the more highly metamorphosed northern and southwestern parts are more coarsely crystalline and provide large reserves of potential ore suitable for concentration.--G.A. Gross.

3-2416. Lamey, Carl A. CONTACT METASOMATIC IRON DEPOSITS OF CALIFORNIA: Geol. Soc. America, Bull., v. 72, no. 5, p. 669-677, map, 4 pls., 3 tables, May 1961, 24 refs.

Fe deposits of California that cluster around small intrusive bodies and are localized in metamorphosed limestone or dolomite show varying degrees of mineralogic complexity. Minerals present along with those that more commonly occur in contact metasomatic deposits in the United States include chondrodite, humite, clinohumite, ludwigite, ilvaite, idocrase, spinel, and forsterite. One deposit is characterized by the very simple mineral assemblage calcite, antigorite, and magnetite except within a few feet of an intrusive body. Generally, pyroxene, garnet, chondrodite, humite, and clinohumite formed early; antigorite, magnetite, specularite, and goethite formed late. The writer suggests several sequences of mineral deposition and compares them

with sequences determined by others.

Addition of material and replacement were prominent in the formation of these deposits. Fe was added during the formation of magnetite, hematite, and goethite and probably also during the formation of hedenbergite, andradite, ludwigite, ilvaite, and epidote; F during the formation of chondrodite, humite, and clinohumite; B during the formation of ludwigite; and probably Mg during the formation of chondrodite, humite, clinohumite, and antigorite. Some recrystallized limestone was replaced by magnetite and antigorite; some antigorite was replaced by magnetite; some pyroxene, minerals of the humite group, and spinel were replaced by magnetite.

The writer classes the deposits as contact metasomatic but suggests that the mineralogy indicates a temperature range from high contact metamorphic to moderate hydrothermal activity.--Auth.

3-2417. Allen, Victor T. COMPARISON OF BAUXITE DEPOSITS OF EUROPE WITH THOSE IN THE U.S.A. (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 16. Genetic Problems of Ores, p. 230-236, 1960) 16 refs.

This study of the bauxite and aluminous laterite deposits of France, Yugoslavia, Greece, Italy, Spain, Germany, and Northern Ireland was supported by a grant of the National Science Foundation in 1957. In all the deposits examined clays composed of kaolinite and locally some montmorillonite minerals occur in association with bauxite minerals and suggest a genetic relationship. Refractory ceramic kaolinite clay and boehmite from Missouri are similar megascopically and microscopically to specimens collected in France and Yugoslavia; also, diaspore specimens from Missouri can be duplicated in the diaspore deposits of Greece. The aluminous laterites of Germany and Northern Ireland derived from basaltic rocks are similar to those of Oregon.

The commercial bauxite of France, Yugoslavia, Italy, Greece, and Spain fills solution pockets in dolomitic limestones. The kaolinite-boehmite diaspore deposits of Missouri also fill pockets in dolomitic limestones formed by ground-water solutions. Clays and alumina hydrates were transported from suitable source areas in Europe and the United States, and were deposited in cavities prepared by solution. Magnesium bicarbonate carried by ground water removed silica from clay to form alumina hydrate minerals. Observations in Georgia, Alabama, Arkansas, Oregon, and Washington suggest desilication of clays can form bauxite.--Auth.

3-2418. Duncan, Craig. THE ALUMINUM INDUSTRY IN AUSTRALIA: Geog. Rev., v. 51, no. 1, p. 21-46, 9 figs., 4 tables, Jan. 1961, refs.

The demand for Al in Australia increased astonishingly between 1954 and 1958. Today Al occupies fifth place by weight among major metals consumed and in volume is outranked only by steel. Under such impetus, the Australian Al industry has developed rapidly, particularly in the exploration and exploitation of domestic bauxite reserves.

In 1955, extensive lateritic deposits in the Cape York Peninsula were identified as bauxite, their quantity and quality are such as to promise complete transformation of the Australian industry. Named the Weipa formation [Tertiary(?)], they lie on the gently dipping western flank of the Cape York geanticline, overlying Tertiary(?) arkosic sands, sandy clays, and silts. Physical conditions found here, or at least simulated, for the formation of aluminous laterite are high mean temperatures, heavy rainfall, abundant supply of organic acids, and sluggish drainage caused by gentle relief.

Australia has both types of alumina (Al_2O_3), trihydrate and monohydrate (including an 8,980-ton reserve on Marchinbar Island). The Weipa formation has 200 mi. of economically usable bauxite, mostly gibbsite (trihydrate), with boehmite (monohydrate) in the upper zone; total reserves of metal-grade bauxite are tentatively estimated at 2,000 million tons, about 55% alumina, 3.5% reactive silica, and 1.5% quartz.

The governmental Australian Aluminium Production Commission and the Tasmanian government developed the Bell Bay Plant, in production since 1955, for converting bauxite to alumina, at Launceston, Tasmania. Production at Bell Bay was 11,370 tons in 1959; ultimately production will be raised to some 40,000 tons annually. Most of the bauxite treated must now be imported, but eventual use of domestic supplies only is a goal. The plant, now supplying only 40% of the current Australian market, was turned over to private industry in 1960.

In 1958, 31,390 tons of semifabricated Al products were produced in 283 secondary manufacturing plants in Australia. Further expansion of the entire industry is inevitable. It is suggested that Australian production may rise to 100,000 tons of Al a year.--R. L. Heinecke.

3-2419. Parsons, G.E. NIOBIUM-BEARING COMPLEXES EAST OF LAKE SUPERIOR: Ontario, Dept. Mines, Geol. Rept. no. 3, 73 p., illus., secs., 5 maps (in pocket), scale 1:15,840, incl. Maps 2005, 2006, 2007, 2008, tables, 1961, refs.

Describes the gross geological and magnetic features of 4 Nb-bearing carbonate-alkaline complexes: Seabrook, Firesand, Nemegosenda, and Lackner.

The Seabrook complex is 1/2 sq. mi. in area. It consists of ijolite, in situ and injected breccias, and carbonatite dikes; the country rocks are granite and diabase dikes. Nb is present as the mineral pyrochlore, but so far no important concentrations have been located.

The Firesand complex is distinctly circular and 1 3/4 sq. mi. in area. A dolomite core is surrounded by calcite carbonatite interzoned with biotite-pyroxene-calcite rock and country rocks of greenstone and granite. Pyrochlore is present in the calcite carbonatite, but no potential ore zones have been defined to date.

The Nemegosenda complex is 9 sq. mi. in area; a core of nepheline syenite is surrounded by a fenite aureole. The country rocks are gneiss. Nb is quite prevalent in the fenites; one zone is reported to contain 20,000,000 tons of 0.5% Nb_2O_5, which is available for open-pit mining. Large tonnages of lower grade material are indicated.

The Lackner complex is 9 sq. mi. in area; it consists of several ring-zones of mafic silicate rocks enclosed in nepheline syenite. Pyrochlore is widespread in the mafic silicate rocks and in apatite-magnetite zones. The complex has been extensively explored, and many millions of tons in several large zones grading from 0.17 to 0.33% Nb_2O_5 are reported. --Auth.

3-2420. Mulligan, Robert. POLLUCITE (CAESIUM) IN CANADA: Canada, Geol. Survey, Paper 61-4, 4 p., 1961, 5 refs.

The paper describes the properties, uses, prices, production, mineralogy, and mode of occurrence of Cs. A substantial deposit of high-grade pollucite has been blacked out at the mine of Chemallay Minerals Ltd., in southeastern Manitoba and a minor amount has been found in Lacorne Township, Abitibi, Quebec. The metal is indispensable in a number of specific applications, but current markets are limited in terms of available suppliers.--M. Stewart.

3-2421. Palmer, Phyllis. SULPHUR UNDER THE SEA: Sea Frontiers, v. 6, no. 4, p. 210-217, illus., map, diag., Nov. 1960.

The Freeport Sulphur Co. has started the first offshore S mine - the Grande Isle project - 7 mi. off the Louisiana coast in the Gulf of Mexico. This S deposit, the third largest in the U.S., spreads over several hundred acres, and varies from 220 to 425 ft. in thickness. Problems of S mining from underwater deposits are discussed. The S is obtained by the Frasch process in which hot water is forced down to melt the S ore, which can then be aerated with compressed air and brought to the surface. A brief history of S concludes the paper.--L. M. Dane.

3-2422. Hewitt, D. F. NEPHELINE SYENITE DEPOSITS OF SOUTHERN ONTARIO: Ontario Dept. Mines, Ann. Rept., v. 69, pt. 8, 194 p., illus. (1 in pocket), maps incl. 2 col. (in pocket), scale 1:31,680, secs. (3 in pocket), diags., graphs, tables, 1960, pub. 1961, refs.

This report is divided into 2 parts. Pt. 1 describes the economic development of nepheline syenite deposits in Ontario, including a history of development of the industry and the history of both the active producing companies at Blue Mountain in Methuen township, Peterborough county. The chemical and mineralogical composition of nepheline syenite is dealt with. Specifications and uses of nepheline syenite in various commercial applications are described. The occurrences of nepheline syenite deposits in Ontario are very briefly described. Sections on grade and evaluation of nepheline syenite deposits, quarrying, and milling complete this part.

Pt. 2, which deals with the geology of nepheline syenite deposits of southern Ontario, is divided into 4 chapters. Chap. 1 is introductory and describes general features of the mineralogy, lithology, weathering, age relations, and field relationships of the Blue Mountain, Haliburton-Bancroft, and French River nepheline syenite occurrences described in the ensuing chapters. Chap. 2 describes the geological occurrence and characteristics of the nepheline syenite deposits of the Haliburton-Bancroft area. The description is by area from W. to E. over a length of 80 mi. Chap. 3 deals with the geology of Methuen township where the extensive Blue Mountain nepheline syenite deposit occurs. Considerable detail is given on the structure and geological history of the area, as well as the field relations of the nepheline syenite body. Chap. 4 describes the geology of the French River nepheline syenite deposits in Bigwood township, district of Sudbury. A discussion of the origin of these nepheline syenite bodies is included. The author's work indicates that, although the bodies are mainly emplaced by intrusion of a nepheline syenite magma, some replacement has occurred.--Auth.

3-2423. Baragar, W. R. A. THE MINERAL INDUSTRY OF THE DISTRICT OF MACKENZIE, NORTHWEST TERRITORIES: Canada, Geol. Survey, Paper 61-3, 29 p., 1961, 8 refs.

The paper describes properties in the prospect and development stages, with the exclusion of fossil-fuel data. A general description of prospecting and exploration activities during the year 1960 is followed by an outline of methods and costs of a helicopter operation used for exploration purposes by several mining companies in recent years. Detailed descriptions of 10 individual mining properties active in 1960 are given. These include Cu, Au, Ni, Mn, and Pb-Zn prospects. Recent developments of the 3 producing Au mines in the area are described.--M. Stewart.

3-2424. Thomson, Robert. PRELIMINARY REPORT ON PART OF COLEMAN TOWNSHIP, CONCESSION V, LOTS 1 TO 6, DISTRICT OF TIMISKAMING: Ontario, Dept. Mines, Prelim. Rept. 1961-4, 118 p., tables, Apr. 1961, refs.

Ontario, Dept. of Mines, Provisional Map P. 97 (GeoScience Abstracts 3-1751) covers the area discussed in this report. A summary of the geological relationships in the area is followed by a description of the mining properties.

3-2425. Davis, Fenelon F. CALIFORNIA MINERAL PRODUCTION IN 1959: California, Div. Mines, Mineral Inf. Service, v. 13, no. 10, p. 1-7, 2 graphs, Oct. 1960.

The decline in California mineral production which began in 1958 continued into 1959. The total value of mineral production in 1959 was $1,424,000,000, off 5% from the total of $1,500,000,000, reported in 1958. The 1958 figure was in return off 9% from the all-time high of $1,650,000,000 reported in 1957. Nevertheless, the total value in 1959 was the sixth highest in the state's history, falling slightly below the figure reported in 1954.

The industrial group of minerals presented an entirely different aspect from that obtained in the overall picture. The total for this group actually registered an increase in value of 12% over 1958. Seven commodities, namely borates, cement, diatomite, gypsum, lime, Mg compounds, sand, and gravel registered an all-time high in quantity and value of production during 1959.--Auth.

3-2426. Bondarchuk, B. G., and others. THE NATURAL RESOURCES OF THE UKRAINIAN SSR AND WAYS OF USING THEM RATIONALLY: Soviet Geography, v. 2, no. 1, p. 12-35, Jan. 1961.

Paleogeographic studies of the Ukraine have as their chief object the discovery of laws of distribution of mineral deposits so as to formulate more productive prospecting for new deposits. The most important mineral resources include Fe, Mn, Ti, and Hg. Other deposits of actual or potential significance include Al, Ni, coal, petroleum, gas, salt, kaolin, evaporites, refractory clay, gypsum, phosphorites, and building stone. Water resources of the Ukraine, while relatively poor, are of great significance in the over-all economy of the country, with extensive power, transportation, and irrigation developments planned or under way. Forests, climate, and animal life are additional aspects discussed.--M. Russell.

See also: Geologic Maps 3-2111, 3-2122, 3-2124, 3-2126; Geophysics 3-2290, 3-2300, 3-2301; Sedimentary Petrology 3-2374; Mineral Deposits 3-2426; Engineering Geology 3-2448.

3-2427. Pixler, B.O. MUD ANALYSIS LOGGING: Jour. Petroleum Technology, v. 13, no. 4, p. 323-326, 5 figs., Apr. 1961.

Mud analysis logging is a direct method of detecting oil and gas in formations drilled. The factors that determine the hydrocarbon content of the drilling mud are discussed. The advantages and disadvantages of the various techniques for separation of gas from the mud and for gas detection are considered.

Examples included show field results of the latest mud logging development – the quantitative analysis of drilling mud for volatile hydrocarbons. Mud analysis provides the means for obtaining valuable formation information not otherwise available. Now, the system furnishes even greater diagnostic data for interpretation.--Auth.

3-2428. Stewart, C.R., and others. THE USE OF ALTERNATING FLOW TO CHARACTERIZE POROUS MEDIA HAVING STORAGE PORES: Jour. Petroleum Technology, v. 13, no. 4, p. 383-389, 5 figs., 2 tables, Apr. 1961, 8 refs.

Storage porosity has been considered one of the important pore geometry characteristics of heterogeneous-porosity limestones. Storage pores are only containers for fluids, in contrast to flow channel pores which both contain fluids and provide continuity for fluid flow. The concept of another geometry characteristic, "porostriction," is presented as a second pertinent variable in describing limestone pore space. In simple terms, porostriction is a measure of the flow resistance between storage and flow channel pores.

Alternating-flow core-testing theory provides flow relationships which can be used to divide the pore space of heterogeneous-porosity media into flow channel and storage pores and to measure the "porostriction" of the latter. Experimental application of this theory to naturally occurring heterogeneous limestones shows that "porostriction" and the ratio of storage to flow channel pores can be estimated.

Porostriction and porosity ratio are microscopic characteristics which should influence oil-recovery efficiencies during certain types of displacement processes. A knowledge of pore geometry should be valuable in designing or selecting the most effective oil-recovery process for heterogeneous limestones containing storage porosity.--Auth.

3-2429. Fanshawe, John R., II. SIGNIFICANCE OF INTERRUPTIONS TO HYDRODYNAMICS IN NORTHERN ROCKY MOUNTAIN PROVINCE, U.S.A. (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 11. Regional and Structural Problems in Oil Geology, p. 7-18, 8 figs., 1960) 4 refs.

Oil generation and initial trapping ceased at the end of Eocene. Later crustal movements were vertical uplifts and local faulting or postvolcanic collapse. The present occurrence of oil and gas represents the residue remaining after the destructive effects of the hydrodynamic and chemical changes during the post-Eocene period of crustal readjustment. Pleistocene hydrodynamic gradients were probably greater than those now being measured.

Critical factors for the retention of oil in closed structures are reviewed for certain known fields and producing areas. Emphasis is placed on structural rather than stratigraphic traps. Taken as example are: Wolf Springs Field, Montana, and Elk Basin, Frannie, Bonanza, and Salt Creek fields, Wyoming.

It is concluded that no tilted water table fields have been found that are the result of present hydrodynamic gradients. Interference with past gradients (due to faulting, sedimentation, or to paraffin or asphalt sealing of a geologically ancient oil-water interface) accounts for most of the pools. Future exploration should search for conditions where simple hydrostatic pressure may be effective as a result of structural or stratigraphic interference to regional hydrodynamics.--Auth.

3-2430. Hutchinson, C.A., Jr., and others. IDENTIFICATION, CLASSIFICATION AND PREDICTION OF RESERVIOR [SIC] NONUNIFORMITIES AFFECTING PRODUCTION OPERATIONS: Jour. Petroleum Technology, v. 13, no. 3, p. 223-230, 8 figs., table, March 1961, 48 refs.

A study of sandstone outcrops typical of producing horizons has been undertaken to develop a method for predicting the size, shape and permeability contrast of reservoir nonuniformities. This paper is a progress report and presents the tentative conclusions reached from the study of several Cretaceous age outcrops in the Four Corners area and of the Woodbine outcrop around Dallas.

The results to date suggest that nonuniformities in sandstone reservoirs may be classified according to 1) depositional environment, and 2) rock texture and cement content. Within a sandstone unit, there will be no drastic variations in permeability providing the cement content is not sufficient to control the permeability. For this noncement-controlled or texture-controlled permeability situation, up to a 5:1 ratio of maximum-to-minimum permeability is expected for measurements on 1 x 7/8-in. core plugs. When the permeability of the sand is cement-controlled, the maximum-to-minimum ratio of permeability values within a sand unit may exceed 100:1.

Clean shale sections tend to be continuous over great distances, whereas sandy shale sections will be fairly continuous only in ripple-marked and horizontally bedded layers of the formation. In cross-bedded sandstones, the sandy shale sections will tend to be discontinuous.

The conclusions reached in this study so far suggest that, if the bedding, textural qualities, and cement content are known in blanket sandstones, the sizes, shapes, and permeability contrast of nonuniformities within the sandstone are predictable. The bedding, textural properties, and cement content can be determined from well cores.--Auth.

A discussion by S. E. Szasz and a reply by the authors are included.

3-2431. Haught, Oscar L., and Wallace R. McCord. ORISKANY GAS DEVELOPMENT AND STRUCTURAL MAP, ONONDAGA-HUNTERSVILLE, WEST VIRGINIA: West Virginia Geol. & Econ. Survey, Rept. Inv. no. 20, 28 p., 2 illus., 3 maps incl. geol. map (under separate cover), scale 1:250,000, chart, table 1960.

In 2 parts: Pt. 1. The Development of Oriskany Gas Production in West Virginia, by Oscar L. Haught, and Pt. 2. Explanation of Onondaga-Huntersville Structural Map, With Information Relative to the Onondaga Group of West Virginia, by Wallace R. McCord. Pt. 1 contains the history and development of Oriskany gas

velopment, along with discussion of the fields in is sand and prospective undiscovered fields. Pt. 2 plains the accompanying map and lists pertinent in- rmation concerning about 300 deep wells drilled in e state. These wells are located on the structural ap.

The map shows structural contours on top of the ondaga-Huntersville formation, with locations of ep wells. Well locations are in 2 categories: 1) ose drilled to the Oriskany and 2) those drilled to e top of the Onondaga limestone-Huntersville chert. ells are numbered so production information con- rning them can be consulted in the report.--I. S. atimer, Jr.

3-2432. Saskatchewan, Dept. of Mineral Resources, etroleum and Natural Gas Branch. PETROLEUM ND NATURAL GAS STATISTICAL YEAR BOOK, 900-1959: 571 p., map, graphs, tables, Regina, ueen's Printer, 1960.

One quarter of all oil produced in Canada now omes from wells in Saskatchewan. This oil finds markets within the province and as far away as Ontario and the United States. This volume provides statistics necessary for an appraisal of the petroleum ndustry. Data are given under the following sections: exploration and development (including land statistics, geophysical and drilling activity, drilling statistics, and oil and gas discoveries), production (crude oil, natural gas, water), disposition, reserves, ratios, value of crude and natural gas-well head prices, refining operations, pipeline transportation.--A.C. Sangree.

3-2433. Thompson, Raymond M. GEOLOGY AND PETROLEUM POSSIBILITIES OF ALASKA (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 11. Regional and Structural Problems in Oil Geology, p. 27-36, 2 figs., 1960).

Alaska is conveniently divided into the northern, central, and southern geologic and physiographic provinces. Northern Alaska includes the Brooks Range and all land to the N. The U.S. Navy successfully explored this area for oil during World War II, drilling 45 core holes and 37 test wells on 18 structures. Three oil fields, 2 gas fields, and several unevaluated indications were found. Known rocks in the area range from the older schists to Devonian and upward into both marine and nonmarine Tertiary. Orogeny, uplift, and emergence occurred several times but not of such diastrophic character as in the other provinces.

In the central province, bounded on the N. by the Brooks Range and on the S. by the great arcuate Alaska and Aleutian ranges, are several potential oil basins. Rocks of all geologic systems from Cambrian to Tertiary are present. Many orogenies with considerable igneous activity affected the province.

Oil seeps were discovered in the southern province by the Russians in 1853, and hundreds of other seeps have since been found. Oil was discovered in 1901 at Katalla, but only 154,000 barrels were produced. Sporadic efforts throughout the province culminated in the first big discovery in 1957 on the Kenai peninsula. All Paleozoic rocks, with the exception of Cambrian, are present. They form a very thick marine sequence deposited in a magmatic geosynclinal belt affected by many orogenies, with intrusive and extrusive activity. Similar conditions existed throughout the Mesozoic and in some areas into the Cenozoic. Major exploratory activity with several deep and important wells is underway.--Auth.

3-2434. North Dakota Geological Survey. PRODUCTION STATISTICS AND ENGINEERING DATA, OIL IN NORTH DAKOTA, FIRST HALF 1960: 111 p., graphs, tables, Dec. 1960.

Data are given on 88 pools. Information for each pool includes: location, discovery date, discovery well, producing formation, datum, deepest test, oil wells, production data 1960 (1st half), accumulative production data to July 1, 1960, reservoir data. Also tabulated are production by pools, oil production by counties, salt water disposal, and drilling statistics. --A.C. Sangree.

3-2435. North Dakota Geological Survey. OIL FIELDS IN THE BURKE COUNTY AREA, NORTH DAKOTA; GEOLOGICAL, MAGNETIC, AND ENGINEERING STUDIES: Its: Rept. Inv. no. 36, 71 p., 37 figs., 1960, 19 refs.

This report contains 4 papers: "Subsurface Studies," by Sidney B. Anderson and others; "Magnetic Map," by Miller Hansen; "Lineaments and Fracture Traces," by David S. Johnson; and "Engineering Data," by Clarence B. Folsom, Jr. An appendix gives field data and performance curves for 14 oil fields.

3-2436. Ellison, Samuel P., Jr. OIL AND GAS IN NORTH-CENTRAL TEXAS, UNITED STATES. (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 11. Regional and Structural Problems in Oil Geology, p. 19-26, 4 figs., 1960) 30 refs.

In this area of more than 42,800 sq. mi. more than 2,615,653,966 barrels of oil have been produced from Paleozoic rocks. Sandstone, conglomerate, and carbonate reservoirs have oil and gas accumulations in both stratigraphic and structural traps. Cambrian, Silurian, Devonian, Ordovician, Mississippian, Pennsylvanian, and Permian rocks reaching a total maximum thickness of about 19,000 ft. prevail in the area. Pennsylvanian and Permian strata contain remarkable carbonate reefs of various kinds which if completely encased in shale form excellent oil and gas traps.

Major structural features include the Bend arch, Electra arch, Muenster arch, Fort Worth basin, Baylor basin, Fort Chadburne fault zone, Concho platform, and the buried Ouachita Mountain overthrust belt. Gently dipping surface strata of Permian, Pennsylvanian, and Cretaceous rocks mask most of the deep subsurface structure.--Auth.

3-2437. Carmical, J. H. NEW OIL DISCOVERY IN AUSTRALIA MAY HAVE GREAT SIGNIFICANCE: New York Times, v. 110, no. 37,724, sec. 3, p. 1, col. 3-7, p. 11, col. 3-5, illus., map, May 7, 1961.

Important showings of gas and oil have been encountered in several producing zones to a depth of 12,000 ft. in a test well drilled in the Great Artesian Basin at Tara, Queensland. Australia, the world's twelfth leading consumer of oil products, has previously failed to locate petroleum deposits in commerical quantity despite encouraging reports from seismic and geologic surveying, about 400 test wells, and government subsidies to companies engaged in oil exploration. The history of oil and gas prospecting in Australia and the activities of the several interests looking for oil in Australia are summarized.--M. Russell.

3-2438. Koppe, Edwin F. COAL - A PETROGRAPHIC APPROACH: Pennsylvania Geol. Survey,

Bull. M-42, 35 p., 13 figs. (2 col.), 2 tables, 1960, 13 refs.

An exposition of coal petrography and its potential value to coal utilization and research. Brief outlines of coal origin and standard analytical methods used are presented. In addition, petrographic nomenclature and techniques are discussed, both for field and laboratory study. Photographic illustrations are employed to clarify the specialized terminology of the field, and a log of the Upper Freeport coal bed is included providing an example of information obtained through petrographic examination. --Auth.

14. ENGINEERING GEOLOGY

3-2439. Parker, John M., III. GEOLOGICAL ENGINEERING CURRICULA: Jour. Geol. Education, v. 9, no. 1, p. 13-18, table, Spring 1961, ref.

Curricula in geological engineering that have been accredited by the Engineers' Council for Professional Development (ECPD) are analyzed in terms of the categories required by that agency. The engineering nature of geological courses is briefly considered as they relate to professional practice in industry. A wide range of curricular requirements has received ECPD approval. Common to almost all programs are a minimum core of calculus, physics, chemistry, and some 30 credit hours of geological courses.--Auth.

3-2440. APPROVED ENGINEER-GEOLOGISTS ANNOUNCED BY L.A. BUILDING AND SAFETY DEPARTMENT: Southwest Builder & Contractor, v. 137, no. 6, p. 44, Feb. 10, 1961.

The Department of Building and Safety, City of Los Angeles, California, has issued an approved list of engineering geologists, dated Feb. 2, 1961, so that property owners contemplating excavating and grading projects in the hillside territory within the city may choose a geologist to make the required report. All those on the list have been approved for the purpose, and their reports will be adopted upon presentation. Names and addresses of the 35 engineering geologists on the approved list are included. --From introd.

3-2441. Woolf, Donald Oliver. THE IDENTIFICATION OF ROCK TYPES: Public Roads, v. 26, no.2, p.44-48, 32, 7 figs., 4 tables, June 1950; reprinted by U.S. Bureau of Public Roads, Washington 25, D.C., 1960 (not seen at AGI).

A method to assist the highway engineer in field identification of rocks is presented, so that he can better select the best types of rock for specific highway construction purposes. The standard classification of rocks, by genesis and mineral composition, is summarized. Simple descriptions are given for sight identification of component minerals and of the rocks themselves, requiring only pocket knife, hand lens, and dilute hydrochloric acid. Important features are a table showing physical properties of principal rock types, based on tests of more than 6,000 samples in U.S. Bureau of Public Roads laboratories, and a summary, in text and tabular form, of the engineering properties of rocks.--E.B. Eckel.

3-2442. Penrod, E.B., and others. VARIATION OF SOIL TEMPERATURE AT LEXINGTON, KENTUCKY: Kentucky, Univ., Eng. Expt. Sta., Bull., v. 15, no. 1, 55 p., 13 figs., 16 tables, Sept. 1960, 12 refs.

Using on earth heat pump system, the University of Kentucky in 1949 began investigating a local lean clay sod-covered soil (Casagrande classification). A size analysis revealed 60% clay and less than 30% silt, and Atterburg classification tests revealed a liquid limit of 43.4% and a plasticity index of 16.1%. The thermal diffusivity of the soil was 0.019 ft.^{2}/hr., a density of 120 lb./ft.^{3}. The specific heat and density of the dry soil were 0.196 BTU/lb./$^\circ$F. and 95 lb./ft.^{3}, and estimated for the wet soil at 0.37 BTU/lb./$^\circ$F.

The research endeavored to determine the average monthly temperature of the soil at various depths in order to develop empirical equations to expedite calculating soil temperatures at any depth at any time of the year. The observed and computed data are tabulated and included. The ensuing data were obtained for the 5-year norm.

Mean surface and/or soil temperature	57.75°F.
Soil temperature amplitude at 0 ft.	21.35°F.
Maximum soil temperature	79.10°F.
Minimum soil temperature	36.40°F.
Thermal diffusivity of soil	0.0279 ft.^{2}/hr.
Wave length of temperature wave	55.5 ft.
Time lag at 10 ft.	2.162 months
Soil temperature amplitude at 55.5 ft.	0.04°F.

--J.E. Garrison.

3-2443. Hampton, Delon, and E.J. Yoder. EFFECT OF RATE OF STRAIN ON THE STRENGTH OF COMPACTED SOIL: Natl. Research Council, Highway Research Board, Bull. 245 (Natl. Acad. Sci.-Natl. Research Council, Pub. 731), p. 27-48, 9 figs., 6 tables, 1960, 27 refs.

The fact that the compressive strength is a function of the time required to reach the failure load has long been recognized. However, this area of soil mechanics has not been extensively explored, and much work remains to be done in order that the effects of this phenomenon can be properly evaluated. The specific areas where this information would be of the greatest benefit are as follows: 1) stability of slopes subjected to earthquakes and other forms of transient loading; 2) transmission of forces from explosions through soils; 3) design of highway pavements; 4) design of airfield pavements.

This paper reports the results of a laboratory investigation of the effects of rate of strain on the strength of remolded soil. Two soils were selected for purposes of this study: a) a clay derived from limestone and pedologically classified as Frederick, and b) a glacial silty clay, pedologically classified as Crosby, "B" horizon. These soils were selected primarily on the basis of their difference in plasticity.

Rate of strain was considered the most important variable and it was studied from 0.55 in./min. to 1,780 in./min. The factors of moisture content and dry density were also of prime importance. Conse-

quently, 3 compactive efforts were used, and specimens were molded and tested on both sides of the optimum moisture content of each compactive effort.

The unconfined compressive strength test was used as the strength criterion, and the effect of the aforementioned variables upon the ultimate strength and modulus of deformation of the samples, as determined by this test, are reported.--Auth.

3-2444. Ladd, Charles C. MECHANISMS OF SWELLING BY COMPACTED CLAY: Natl. Research Council, Highway Research Board, Bull. 245 (Natl. Acad. Sci.-Natl. Research Council, Pub. 731), p. 10-26, 12 figs., 2 tables, 1960, 22 refs.

In several areas of the world the differential heaving of foundations due to the swelling of highly plastic clays has resulted in severe damage to buildings. Swelling of clay also changes the engineering properties of strength, compressiblity, and permeability. For many earth structures, such as road subgrades and embankments, a loss of strength or an increase in compressibility will be of greater concern to the soil engineer than the heaving per se. As the use of clay, and especially highly plastic clay, for earth structures increases, the need for a better understanding of the swelling phenomenon becomes greater, since the soil engineer must not only know the "as-compacted" properties of clay, but also know how these properties change with time.

The mechanisms believed to cause swelling in saturated clay-water systems are first reviewed. These concepts, drawn primarily from soil chemistry and soil physics, are extended to compacted natural clays. Test data are presented to show the effects of the ion concentration in the pore fluid on the swelling behavior of a highly plastic clay. These data consist primarily of heaving and fluid pickup measurements on samples molded with pure water and soaked in solutions of varying salt concentrations.

For the clay investigated, it is concluded: 1) For samples compacted wet of optimum water content, swelling can be explained by osmotic repulsive pressures arising from the difference in ion concentration in the double-layer water between interacting clay particles and that in the free pore water. 2) For samples compacted dry of optimum water content, swelling is influenced by factors in additions to osmotic pressures. These other factors may be: the effect of the negative electric and London van der Waals force fields on water, cation hydration and the attraction of the particle surface for water, elastic rebound of particles, a flocculated particle orientation, and the presence of air. The relative importance of these other factors is not known.--Auth.

3-2445. ROADBUILDERS CONQUER 'THE BOG' IN NORTHERN MANITOBA: Roads & Engineering Construction, v. 98, no. 4, p. 106-109, Apr. 1960.

A formidable obstacle on a 109-mi. reconstruction job on No. 10 highway between Mafeking and The Pas, Manitoba, was a 14-mi. long muskeg known as 'The Bog,' having depths of peat up to 14 ft. Some 1,300,000 cu. yd. of soggy peat were dug out by draglines and the trench backfilled with clay excavated from ridges marking the edges of the one-time lake. Most of the muskeg was below the water table, so the work was done in winter. Water from the edge of the grade was kept back by the simple expedient of letting it freeze. After packing, settling and trimming, the road surface will be 7 ft. above the bog level. It replaces an old floating road, built on a base of logs on top of the muskeg during 1938. The new high standard subgrade of the reconstructed highway will enable it to carry a permanent paved surface.--Courtesy Canadian Building Abstracts 120, Oct. 1960.

3-2446. Metcalfe, Bob. MUSKEG CAN'T STOP MANITOBA ROAD WORK: Civic Adm., v. 12, no. 6, p. 55, June 1960.

One of nature's formidable obstacles to highway building - a postglacial mass - has been conquered in northern Manitoba. The project provides a 14-mi. link between Mafeking and The Pas through bog where muskeg to a depth of 14 ft. was found. This was dug out and replaced with clay which was drawn from the edges of a nearby one-time lake. Because most of the muskeg was below the water table the job could only be done in winter. The gravelled grade will be some 7 ft. above the surrounding bog.--Courtesy Canadian Building Abstracts 114, Oct. 1960.

3-2447. ROADBUILDERS ADAPT TERRACE GRAVELS AS PAVING MATERIALS: Pacific Builder & Engineer, v. 66, no. 12, p. 73-74, 2 illus., Dec. 1960.

Scarce conventional aggregates in the Coos Bay area of Oregon has encouraged the use of terrace gravels for Highway 101 construction. The gravels are in layers separated by fine sand and capped by a few feet of overburden. The terrace is about 50 ft. above sea level and may represent a bar developed when sea level was higher.

About 60% of the material passes the No. 10 sieve and is 90% retained on the No. 40 sieve. The size gradation and excellent rounding promote free drainage and consequent loss of stability. Rejection of approximately half of the minus No. 10 material, drying of the remainder, and addition of 5% asphalt binder results in a satisfactory base course.--W. N. Laval.

3-2448. Rinehart, John S., and William C. Maurer. FRACTURES AND CRATERS PRODUCED IN SANDSTONE BY HIGH-VELOCITY PROJECTILES: Jour. Petroleum Technology, v. 13, no. 3, p. 273-276, 10 figs., table, March 1961, 4 refs.

The mechanics of impact crater formation in rock, particularly sandstone, has been studied, the velocity range being approximately that normally associated with oilwell gun perforators. The bullets were small steel spheres having diameters of 3/16, 9/32, and 7/16 in.; impact velocities ranged from 300 to 7,000 ft./sec. The craters have 2 distinct parts – a cylindrical hole (or burrow) with a diameter the same as that of the impacting sphere, and a wide-angle cup comprising most of the volume of the crater. The burrow is formed as material in front of the projectile is crushed and pushed aside, forming a cylindrical hole surrounded by a high-density zone. The cup forms as fractures are initiated in front of the projectile and propagate along logarithmic spirals, approximating maximum shear trajectories, to the free surface of the rock.

A most significant observation (made for the first time) was that, below the base of the cup in one type of sandstone, there are a group of similar fractures, not extending to the surface, which are spaced uniformly a few millimeters apart. Each fracture follows roughly the contour of the base of the cup and appears to require a certain threshold impulse to initiate it. These fractures comprise a relatively

high fraction of the total, newly exposed surface area. The volume of the material removed by crushing varies as the first power of the impact velocity and the volume removed by fracturing, as the second power of the impact velocity. Penetration varies linearly with the impact velocity and is inversely proportional to the specific acoustic resistance of the target material, the proportionality constant being dependent upon the shave of the projectile.--Auth.

3-2449. Gordon, Arthur, and Frank E. Burkett. YOU CAN CONTROL PILE-DRIVING CLAIMS: Contractors and Engineers Mag., v. 58, no. 2, p. 56-59, 3 illus., Feb. 1961.

By using an accelerometer it is possible to measure the earth vibrations caused by pile-driving operations. Because the characteristics of the earth materials governs ground vibrations, it is important that these be determined by a qualified engineer or consultant. The method of driving and the design of the piles can be selected in such a way as to keep vibration intensities below the standard safe limits for plaster walls and ceilings. Driving in areas of high water table or rubble fills create the most problems but the standard operation in hard or firm sand usually creates no problems outside a circle with a radius equal to the depth of the pile.--J. E. Goffman.

3-2450. California, University, Radiation Laboratory, Livermore. NUCLEAR EXPLOSIVES AND MINING COSTS. By Fred L. Smith and Thomas R. Young: U.S. Atomic Energy Comm., [Pub.] UCRL-5928, Contract W-7405-eng-48, 37 p., July 1960 (not seen at AGI).

An interesting application of nuclear energy to mining operations is the proposed use of nuclear explosives to shatter a buried ore body so that the ore may be leached in situ. This method offers intriguing possibilities for profitable mining of low-grade deposits that would not repay the cost of mining by conventional means. Cost estimates indicate that the nuclear method would be less expensive than the presently used block-caving method, especially for very large ore deposits.--Auth. (courtesy Nuclear Science Abstracts, v. 14, no. 24A, p. 3330, Dec. 31, 1960).

3-2451. Philbrick, Shailer S. CYCLIC SEDIMENTS AND ENGINEERING GEOLOGY (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 20. Applied Geology, p. 49-63, 5 figs., 1960) 8 refs.

Cyclic sediments in the Allegheny Plateau area of western Pennsylvania, eastern Ohio, and West Virginia represent a special case of the sandstone and shale foundation problem complicated by the interbedded addition of thin limestones and mineable coals and the repetition of the whole sequence of beds. The cycle assumed for discussion in this paper is an 8 member cycle with the sandstone as the base, and is reasonably typical of complete cycles in the Pennsylvanian rocks of this area. The beds in ascending order are: sandstone, sandy shale or indurated clay (claystone), limestone, underclay, coal, carbonaceous shale, limestone, and sandy ferruginous shale. The top 3 beds are marine and the underlying members are nonmarine. Cyclic sediments cause problems in engineering geology because the cycle is composed of rocks of widely differing geological, physical, and chemical characteristics. Some of these characteristics are tabulated and illustrated photographically. These problems are outlined in relation to this assumed cycle, and typical examples of these problems encountered in the investigation, design and construction of dams, reservoirs, navigation structures, railroads and high buildings are described.

The desirable foundation bed for a concrete dam in this cycle is the basal sandstone. Assuming a dam to be more than the height of a single cycle, the next sandstone will be found up in the abutments. But between the 2 sandstones lie a series of weaker shales, clays, coal and limestone, which are less suitable as foundation materials than sandstones. These weaker rocks may require redesign of the portion of the dam resting upon them or may require stepping over some of them to a bearing bed of sufficient thickness and strength to spread to the loads on the weakest members.

The rate of weathering of the members differs greatly. In designing permanent cut slopes for railroad, highway, and dam construction the differential weathering, as well as the variation in strength of the several members of the single or successive cycles must be recognized in order to reduce the hazards of landslides, rock falls, and ravelling which would raise maintenance costs and create dangers to operations.

Mining of the coal, limestone, refractory clays, and shales in the cycles creates serious problems of support or leakage which may require expensive and difficult remedial treatment.

The cyclic sediments present a suite of repetitious problems in engineering geology, many of which may be suspected, investigated, and treated successfully as soon as the cyclic character of the rocks is recognized.--Auth.

3-2452. MacKenzie, G. L. THE SOUTH SASKATCHEWAN RIVER DAM: Engineering Jour., v. 43, no. 5, p. 50-55, May 1960.

The South Saskatchewan River dam is the principal structure in a large multiple purpose project in central Saskatchewan, now under construction. When completed the project will irrigate an area of approximately 500,000 acres in a region that has experienced severe drought conditions. It will provide flood control to all areas along a 400-mi. reach of the South Saskatchewan River and permit the development of about 475 million kwh. annually. Central feature of the project is an earth-fill dam, 210 ft. in height, which will contain 45 million cu. yd. of material, about one-half impervious and one-half pervious. Five diversion tunnels 20 ft. in diameter and about 4,000 ft. long are necessary for construction, excavated through the local Bearpaw shale, a heavily over-consolidated compact clay. The spillway will be a reinforced concrete chute with a gated crest designed to discharge a flood flow of 400,000 c.f.s.--Courtesy Canadian Building Abstracts 124, Oct. 1960.

3-2453. Nelson, Paul. BLACK BUTTE DAM CONTRACTOR WORKS ODDBALL MATERIALS: Pacific Builder & Engineer, v. 67, no. 2, p. 82-83, 2 illus., Feb. 1961.

Black Butte Dam, a U.S. Army, Corps of Engineers project near Orland, California, is a flood control structure on Stony Creek, a tributary of the Sacramento River. The foundation rock is "mudstone" (semiconsolidated mixture of clay, silt and

and), capped by basalt. Weathering along joints in the basalt caused the failure of the downstream portal of the river control tunnel. Grout take in the mudstone under the main embankment area averaged a half sack per foot of hole. Random rockfill and riprap are obtained from spillway excavation in the left abutment. Pervious materials are obtained from upstream and downstream borrow areas.--W. N. Laval.

3-2454. Nelson, Paul. SPILLWAYS RISE AT JOHN DAY DAM: Pacific Builder & Engineer, v. 66, no. 11, p. 64-67, 10 illus., Nov. 1960.

John Day Dam on the Columbia River [Washington-Oregon] is being built under contract for the U.S. Army, Corps of Engineers. The dam will be 5,900 ft. long at the crest, will have a normal head of 105 ft., and the reservoir will extend 76 mi. upstream when it is completed in 1967.

Present construction of the navigation lock on the N. shore and part of the adjacent spillway has encountered no severe foundation problems in the highly jointed basalt bedrock. The initial grout curtain has required about one-half sack of cement per foot of hole. Later 3 stages will extend the curtain to about 140 ft. depth from a grouting gallery in the concrete structure. About 30,000 to 50,000 gallons of water per minute are pumped from the working area. Part of this water comes through the rock because excavation has nearly reached the bottom of the initial grout curtain. Minor difficulty has arisen because of gravel-filled potholes and slots in the river channel.

About 1 million cubic yards of concrete will be poured under the N. shore contract. Supplies of gravel are ample on the N. shore upstream from the dam. A deficiency of coarse gravel necessitates crushing cobbles. Sand is obtained from a deposit about 1 mi. S. of the site on the John Day River.--W. N. Laval.

3-2455. Nairne, Virginia. WORLD'S LARGEST GROUT CURTAIN BUILT AT -50°: Engineering & Contract Record, v. 74, no. 2, p. 76-78, 4 illus., diag., Feb. 1961.

250 mi. N. of Winnipeg work has started on the construction of the 450,000 h.p. Grand Rapids water power development of the Manitoba Hydro-Electric Board. Located at the mouth of the Saskatchewan River in Lake Winnipeg, operating head will be 125 ft., made possible by the possibility of constructing earth dikes to this height. Bedrock is a cavernous limestone. Subsurface exploration has shown the necessity for a continuous cement grout curtain beneath the long retaining dikes. When complete this will be 19 mi. long and 200 ft. deep, requiring 2,000,000 bags of cement and 1,500,000 ft. of drilling. Holes at 5-ft. centers are being drilled and grouted in 4 stages.--R.F. Legget.

3-2456. Marek, Charles E. CAST-IN-HOLE PILES USED ON LOOP JOB: California Highways & Public Works, v. 40, no. 1/2, p. 14, 24, 3 illus., Jan.-Feb. 1961.

Four-ft. diameter cast-in-drill-hole friction piles were used successfully on the Santa Monica Freeway Viaduct in Los Angeles in place of a larger number of conventional small diameter piles. Geologic conditions were determined by borings to a maximum depth of 85 ft. Material encountered was silty sand with lenses of cobbles; bearing values ranged from 1 ton per sq. ft. near the surface to 5 tons per sq. ft. below 40 ft. depth. Ground water was absent.

Design loads averaged 450 tons per pile with average pile length of 40 ft. Because of this unusual use of piles and size of the loads, test loads of twice the design load were required. The test pile was loaded by hydraulic jacks working against a reinforced concrete reaction beam. Permanent settlement and rebound were measured. Where geologic conditions permit this type of pile (no ground water and material that does not cave when drilled), large diameter cast-in-hole piles may find many uses in the future. In this case, nearly 50% savings over conventional piles were realized.--E. B. Eckel.

3-2457. MacLaren, J. W., and others. A DEEP PUMPING STATION FOR THE OTTAWA SEWAGE TREATMENT PLANT: Engineering Jour., v. 43 no. 5, p. 56-63, May 1960.

Ottawa is embarking upon a major sewerage and sewage treatment project, the main plant for which is to be located about 6 mi. downstream from the center of the city on the bank of the Ottawa River. The program will cost approximately 21 million dollars of which expenditure on plant will amount to about 40%. The pumping plant is designed to handle the raw sewage from an estimated population of 375,000 persons anticipated by 1975 at the rate of 40 million gallons per day. The plant is to be founded on sensitive marine clay and will be built as a concrete boxlike structure extending almost 100 ft. below surface level, its bottom slab supported on bored piles carried to the underlying rock. Extensive soil studies have been carried out at the site in view of the known properties of the local "Leda" clay in which the plant must be built.--Courtesy Canadian Building Abstracts 125, Oct. 1960.

3-2458. Kaser, Kent S. EXCAVATION AND PIPE FOUNDATIONS FOR SEWAGE COLLECTION SYSTEMS: Water & Sewage Works, v. 108, no. 1, p. 32-36, 5 figs., table, Jan. 1961, ref.

The excavation of trenches and preparation of foundations for sewers is becoming a major problem in many areas. The increasing cost of planning, design, materials, and construction necessitates considering the natural materials and conditions to insure the most permanent installation.

In soft sandy soils every excavation is achieved by backhoe or clamshells. The pipe will tend to bed itself. Caving conditions normally require continuous cribbing. Well point systems are necessary instead of sump pumps, for upon removal of sump, the rising water may float and disturb the pipe joints allowing sand to infiltrate, and also to prevent difficulties in compaction of the replaced soil material.

Damp medium stiff to stiff clay soils are excavated readily by a backhoe or a trenching machine. Interval cribbing is desirable. Since foundation trimming is expensive, the trench is excavated 4 in. below the bed elevation and refilled with sand. Soft wet clay soil caves easily, is hard to dewater, and forms unstable foundations. Therefore continuous sheeting and up to 3 ft. of compacted stable backfill is needed for bedding material.

Rock excavation is costly and always requires trenches that are 4 to 12 in. deeper than bed elevations and refilling to bed elevation with sand and gravel. Ground water is simply controlled by sump pumps. In nonpervious rocks the refilled trench will collect water; therefore, all joints are sealed.

Borrow material is often required to refill the trench, and rock must be disposed.

Soft sandstone and coral can often be excavated with trenching machines having special hardened bucket teeth.--J. E. Garrison.

3-2459. Earthquake Engineering Research Institute. TRANSLATIONS IN EARTHQUAKE ENGINEERING. Translations of Papers Published in the Russian Language: 150 p., illus., maps, diags., graphs, tables, 465 California Street, San Francisco 4, California, 1960, refs.

CONTENTS:

The Fundamental Premises of the Dynamic Theory of Seismic Resistance, by M. T. Urazbaev and others.

A Method of Designing Buildings for Seismic Forces, by I. L. Korchinsky.

The Design of Flexible Structures for Seismic Loads, by I. L. Korchinsky.

A Simplified Method for Earthquake Resistant Design of Structures, by A. G. Nazarov and B. K. Karapetyan.

On the Interaction Between Masonry Filler Walls and Enclosing Frame When Loaded in the Plane of the Wall, by S. V. Polyakov.

Certain Design Problems of Reinforced Concrete Frame Structures for Seismic Regions, by V. F. Kulakov.

Vibration of Tall Buildings, by I. L. Korchinsky.

Standards and Regulations for Building in Seismic Regions, by the State Construction Committee of the Council of Ministers of the U.S.S.R.

Section 1: Zones and Design Ratings.
Section 2: Planning Cities and Towns.
Section 3: Seismic Forces.
Section 4: Industrial and Civic Buildings.
Section 5: Water Works and Sewage.
Section 6: Highways and Railways.
Section 7: Hydraulic Structures.
Section 8: Rural Structures.
Section 9: Field Work and Control.
Appendix 1: Earthquake Zones.

Notes on the Comparison Between GEOFIAN Intensity Scale and Modified Mercalli Scale, by the E.E.R.I. Translations Committee.

3-2460. Texas, University, Civil Engineering Research Laboratory, Austin. REACTOR FUEL WASTE DISPOSAL PROJECT; DEVELOPMENT OF DESIGN PRINCIPLE FOR DISPOSAL OF REACTOR FUEL WASTE INTO UNDERGROUND SALT CAVITIES. By Shosei Serata and Earnest F. Gloyna: U.S. Atomic Energy Comm., [Pub.] TID-6317, Contract AT(11-1)-490, 189 p., Jan. 1959 (not seen at AGI).

Waste disposal in underground salt cavities is considered. Theoretical investigations for spherical and cylindrical cavities included analysis of elastic stress, thermal stress, and stress redistribution due to the development of a plastic zone around the cavity. The problems of temperature distribution and accompanying thermal stress, due to heat emission from the waste, were also studied. The reduction of the cavity volume, the development of the plastic zone, and the resulting stress redistribution around the cavity are presented as functions of cavity depth, internal pressure of cavity, strength of salt, and cavity temperature rise. It is shown that a salt cavity can be designed so that it is structurally stable as a storage container, assuming a chemical equilibrium can be established between the liquid waste and salt.--W.D.M. (courtesy Nuclear Science Abstracts, v. 14, no. 22, p. 3081, Nov. 30, 1960).

3-2461. Repenning, Charles A. GEOLOGIC SUMMARY OF THE CENTRAL VALLEY OF CALIFORNIA WITH REFERENCE TO THE DISPOSAL OF LIQUID RADIOACTIVE WASTE: U.S. Geol. Survey, Trace Elements Inv. Rept. 769, 69 p., 14 figs. (3 in pocket), 1960, 59 refs.

The Central Valley of California lies W. of the Sierra Nevada and E. of the Pacific Coast Ranges. It is about 450 mi. long and has an average width of about 40 mi. The northern part is drained by the Sacramento River and is called the Sacramento Valley. Much of the southern part is drained by the San Joaquin River and the remainder has an interior drainage; the southern part is called the San Joaquin Valley.

As much as 6 mi. of sedimentary rocks accumulated in the San Joaquin Valley and as much as 10 mi. in the Sacramento Valley. Most deposits in the Sacramento Valley are composed of Cretaceous sandstone and siltstone with little regional variation. The deposits in the San Joaquin Valley, by contrast, are largely Tertiary sandstone, siltstone, and claystone with great regional variation in rock types. The complexity of the facies of the Tertiary rocks has resulted in a large stratigraphic nomenclature, and much of it, because most of the information is from well data, is loosely defined and of informal nature. It is, nevertheless, widely used, and must be used in any regional summary of the stratigraphy.

Cretaceous deposits are largely marine, but the Tertiary rocks contain a high proportion of continental deposits that are increasingly abundant in the younger parts of the stratigraphic section. Many stratigraphic traps of several types are present that might be used to store liquid waste. The potentially useful stratigraphic storage reservoirs are common and the selection of more favorable areas for waste disposal is influenced by areas of favorable geologic structure.--Auth.

3-2462. Bowen, Boone M. Jr., and others. GEOLOGICAL FACTORS AFFECTING THE GROUND DISPOSAL OF LIQUID RADIOACTIVE WASTES INTO CRYSTALLINE ROCKS AT THE GEORGIA NUCLEAR LABORATORY SITE (In: International Geological Congress. 21st, Copenhagen, 1960. Report, Pt. 20. Applied Geology, p. 32-48, 7 figs., 1960) 11 refs.

The various facilities of the Georgia Nuclear Laboratory, operated by Lockheed Aircraft Corporation for the U.S. Air Force, consist of 2 nuclear reactors and radiation laboratories. As a result of these operations, quantities of liquid radioactive wastes are generated. These wastes are disposed of by infiltration basins constructed into the weathered and chemically altered saprolite derived from a crystalline complex of schists, gneisses, amphibolites, quartzites, and related rocks. The lithologic and structural features influencing the movement and decontamination of the waste material are described. Detailed hydrologic investigations have been made, and some of the results are discussed.

Many problems exist in the safe and economic disposal of radioactive wastes. A description of the disposal systems and methods used at the Georgia Nuclear Laboratory, including maximum permissible concentrations and the program of environmental monitoring, is presented.--Auth.

2463. - Brown, Randall E. THE USE OF GEO-HYSICS AND GEOCHEMISTRY TO CONFIRM EOLOGICAL INTERPRETATIONS AT THE HAN-ORD WORKS OF THE ATOMIC ENERGY COM-ISSION, USA (In: International Geological Con-ess. 21st, Copenhagen, 1960. Report, Pt. 2. eological Results of Applied Geochemistry and eophysics, p. 75-82, 2 figs., 1960) 3 refs.

Disposal of low-level radioactive waste to ground quires knowledge of geological and hydrological atures and their quantitative significance to degrees rely achieved in other geologic fields. The Han-rd Works, [Richland, Washington], has determined any of these by geochemical and geophysical data, niquely applied.

Beds are correlated between many wells by de-iled comparisons of samples and drilling records, ay mineral studies, exchange capacity and particle ze distribution studies. Data from ground water tudies also corroborate the interpreted geology and efine its significance. These include natural salts istribution, regional water table studies, well ydrograms, tracer tests, special in-well tests, quifer performance tests, seasonal effects of the olumbia River on the ground-water system, and ffects of ground water formed by discharge of large olumes of cooling water to ground.

The use test, a form of tracer test where dis-harged wastes are traced by sampling and testing nany monitoring wells, provides the final evaluation f the significance of the determined features.

These studies also demonstrated the importance f ground water mounds as means by which ground water flow rates and flow directions can be altered, f desired, to help assure safer waste disposal.--Auth.

3-2464. General Electric Company, Hanford Atomic Products Operation, Richland, Washington. A TEST OF THE REFRACTION SEISMIC METHOD ON THE HANFORD PROJECT: By John R. Raymond and C. A. Ratcliffe: U.S. Atomic Energy Comm. [Pub.] HW-61796, Contract AT (45-1)-1350, 21 p., Sept. 1959 (not seen at AGI).

An investigation was made to test the practicability of seismic geophysical exploration for investigating geologic and hydrologic features affecting ground disposal of liquid radioactive wastes. The theory of the refraction seismic method of geophysical investigation is briefly discussed. The method was tested on the Hanford project by use of a laboratory-built single-channel seismograph. The instrument generally operated adequately, and the tests were successful. The method was tried at 2 sites, one selected to attempt detection of the ground-water surface and the other to attempt detection of the basalt bedrock surface. At both sites the responding horizon was less than 50 ft. below the surface. In both cases the surface of the responding horizon was delineated within accuracy of a few feet. It is concluded that seismic survey with well-developed commercial instruments will provide valuable knowledge of depth to basalt and other geologic horizons.--W.L.H. (courtesy Nuclear Science Abstracts, v. 14, no. 22, p. 3081, Nov. 30, 1960).

3-2465. Beaton, John L. and Richard F. Stratfull. CULVERT LIFE: California Highways & Public Works, v. 40, no. 1/2, p. 43-47, 6 illus., chart, Jan.-Feb. 1961.

All steels used in corrugated metal culverts are subject to corrosive attack by ground water or atmospheric elements. Two simple semi-empirical field tests - determination of pH and of electrical resistivity - are made of surface waters, ground waters, and soil or rock with which the culvert comes in contact. With these measurements, the life of metal culvert can be estimated accurately from a chart.--E.B. Eckel.

3-2466. Hartley, Robert P. BOTTOM DEPOSITS IN OHIO WATERS OF CENTRAL LAKE ERIE: Ohio, Div. Shore Erosion, Tech. Rept. no. 6, 14 p., 7 pls., incl. 3 maps, scale approx. 1:170,000, Jan. 1961.

The bottom reconnaissance sampling program carried out by the Ohio Division of Shore Erosion has covered all of the Ohio waters of Lake Erie. This report includes that part from the island area eastward to the Ohio-Pennsylvania line. The samples were taken with a 2-qt. snapper sampler. Sampling density varied from 1 sample per sq. mi. to 1 per 4 sq. mi. Some depth sampling was also done by coring and jetting. All samples were mechanically analyzed for grain sizes and sorting.

Central Lake Erie is flat for the most part, with a mud bottom. Slopes of any consequence are found only along shore in sand, gravel, and rock areas and in the commercial sand deposit N. of Vermilion, Ohio. As a whole, the bottom surface deposits of the Ohio portion of central Lake Erie are composed of 22.5% sand and gravel, 76.6% silt and clay(mud), and 0.9% rock.

The bottom deposits are derived mainly from glacial deposits with bedrock supplying a lesser but still large amount. Sands, gravels, and muds are probably transported and redeposited by water currents and waves. Small areas of till and lag deposits of pebbles and cobbles have been found near shore, especially from Cleveland eastward. The coarser materials everywhere reflect the composition of the bedrock nearest at hand. Large quantities of sand and gravel of potential commercial value have been found near shore from Cleveland to Fairport and in mid-lake between Ashtabula and Conneaut.--From auth.

15. MISCELLANEOUS

-2467. Burgunker, Mark E. RUSSIAN-ENGLISH ICTIONARY OF EARTH SCIENCES: 94 p., New ork, Telberg Book Co., 1961.

Presented here are English counterparts of those ussian terms which constitute the "hard core" of the omenclature of tectonics, geomorphology, hydrology, aleogeography, and geophysics. A number of botanical, zoological, and ecological terms utilized by the earth scientist are included. In the choice of Russian terminology, the nomenclature in A.S. Barkov's Slovar-Spravochnik po Fizicheskoi Geografii (Dictionary and Manual of Physical Geography), Moscow, 1954, was treated as a yardstick for the type of vocabulary presented, because of the growing importance of such disciplines as paleobotany and ecology in the earth sciences.--From auth. pref.

3-2468. King, Ruth Reece, and others. BIBLIOGRAPHY OF NORTH AMERICAN GEOLOGY, 1958: U.S. Geol. Survey, Bull. 1115, 592 p., 1961.

The current volume lists publications that appeared during 1958 on the geology of the United States (including Alaska and Hawaii), the rest of the North American continent including Greenland, the West Indies, and adjacent islands, and also Guam and other Pacific island possessions - but not the trust territories of the United States. A few articles published before 1958 and not included in previous volumes, are cited also. Articles by American authors published in foreign journals are cited if they deal with North American localities or are of a general nature, but not if they deal only with foreign areas. Articles on North America by foreign authors are included regardless of place of publication while those of a general nature are included only if they appeared in North American journals.

The citations are listed alphabetically by author, with full title and publication data. There follows a subject index to the papers cited.--From introd.

3-2469. Jillson, Willard Rouse. A BIBLIOGRAPHY OF THE CUMBERLAND RIVER VALLEY IN KENTUCKY AND TENNESSEE. CITATIONS OF PRINTED AND MANUSCRIPT SOURCES TOUCHING UPON ITS HISTORY, GEOLOGY, CARTOGRAPHY, COAL, IRON, SALT, FLUORSPAR, PHOSPHATE, CLAYS, OIL AND GAS, WITH ANNOTATIONS: map, Frankfort, Kentucky, Perry Publishing Co., 1960, refs.

A bibliography of 243 briefly annotated items arranged chronologically from 1674 through 1960. The papers are listed alphabetically by author under each year.--L. M. Dane.

3-2470. Nova Scotia, Dept. of Mines. ANNUAL REPORT ON MINES, 1960: 127 p., illus., 23 tables, Halifax, 1961.

Includes report on industrial minerals, metalliferous mines, petroleum exploration, and government core drills, and the reports of the Geological Division and Cartographic Division.

3-2471. Kansas, State Geological Survey. ACTIVITIES OF STATE GEOLOGICAL SURVEY OF KANSAS, FISCAL YEAR ENDING JUNE 30, 1960. Prepared by Grace Muilenburg: Its: Misc. Rept., 44 p., illus., maps, graphs, tables, Jan. 1961.

The fiscal year 1959-1960 was one of continued progress for the Geological Survey. Two events of the year pointed especially to increased activity in the future. One was the appropriation of $50,000, to be matched by an equal amount from U.S. Geological Survey funds, for expanded ground-water activities in fiscal 1960-1961; the other was the completion, dedication, and occupation of the Wichita Well Sample Library.

In connection with detailed plans for the accelerated ground-water program, near the close of the year additions were made to the staff in Lawrence and at Garden City, headquarters for study in the irrigation area of western Kansas. In Wichita, so many donations of well samples were received from oil companies that the Well Sample Library was occupied to capacity early in 1960 and an addition became necessary even before the building was a year old.

Within the Survey, the Divisions of Geochemistry and Industrial Minerals and Ceramics were consolidated into the Division of Ceramics and Geochemistry and the palynology laboratory placed under the supervision of the Division of Mineral Economics and Coal. Preparatory to making the Wichita Well Sample Library a distribution center for oil and gas information in S.-central Kansas, a geologist was placed in charge in June 1960.--Director's summ.

3-2472. Michigan, University, Great Lakes Research Division. PROCEEDINGS, THIRD CONFERENCE ON GREAT LAKES RESEARCH, PRESENT STATUS AND FUTURE NEEDS, ANN ARBOR, MICHIGAN, May 6-7, 1959: Its: Pub. no. 4, 160 p., illus., maps, charts, graphs, tables, Ann Arbor, 1960, refs.

Papers of geologic interest include: 1) Great Lakes Geophysical Research Group, Status Report, by David V. Anderson, p. 31-33; 2) Bibliography of Published Geologic Papers and Unpublished Theses of the Great Lakes and Their Drainage Basins, 1950 Through 1958, p. 51-59; 3) A Report on the Status of Lake Erie Geological Research in Ohio, by Howard J. Pincus, p. 95-107, dealing with work of the Ohio Division of Shore Erosion.--A. C. Sangree.

3-2473. Krasilnikova, N. V. GEOLOGICAL MAPS IN NATIONAL ATLASES: Soviet Geography, v. 2, no. 5, p. 33-41, 2 tables, May 1961.

Reviews the group of geological maps in national atlases, comparing the form and content of geological-stratigraphic, tectonic, mineral-deposits, lithological-petrographic, and Quaternary-deposits maps and making recommendations for greater uniformity of such maps in national atlases.--Auth.

3-2474. Washburn, Bradford. A NEW MAP OF MOUNT McKINLEY, ALASKA; THE LIFE STORY OF A CARTOGRAPHIC PROJECT: Geog. Rev., v. 51, no. 2, p. 159-186, 24 illus., 3 maps incl. col. map (in pocket), scale 1:50,000, diag., Apr. 1961, refs.

The article traces the inception, development, and final realization, over a period of 25 years, of a personal dream to produce a map of Mt. McKinley that would be "unusually beautiful, but also as accurate as it would be reasonable to expect of a reconnaissance sheet of so rugged and remote a region." The author treats, in narrative form, the ground and aerial survey work accomplished during his 7 trips to Alaska in 15 years and describes the cooperative effort of the nearly 200 persons who participated directly in the project. The final map, on the scale of 1:50,000, represents not only the most reliable survey data and photography available, but also the finest techniques in contouring, hill-shading, and printing - the work of a team of expert Swiss cartographers.--W. B. Fairchild.

An abstract of the map appears in Sec. 1, Pt. 1, Geologic Maps.

3-2475. Hughes, R. J., Jr. THE ENLARGER AS A COPY CAMERA: Jour. Geol. Education, v. 9, no. 1, p. 27-28, 4 illus., Spring 1961.

The geology teacher is frequently faced with the necessity of making out with the equipment at hand. A photographic technique using a standard enlarger as a copy camera should prove to be a help to

achers needing fine copy work done at minimum pense and trouble. Only 3 items are necessary: an dapter back, a pair of copying lamps, and a home- ade reflex viewer.--Auth.

-2476. Johnson, Robert B. TEACHING GEOLOGY Y TELEVISION: EFFECTIVE METHOD OR GIM- ICK?: Jour. Geol. Education, v. 9, no. 1, p. -26, Spring 1961.

Increased use of televised geology courses has een accompanied by favorable and unfavorable state- ents about its effectiveness. Television instruction ermits greater use of visual material and requires ore thorough teacher preparation. College admin- strations benefit from the scheduling flexibility and eduction of staff teaching loads. The major dis- dvantages, loss of student-teacher contact and tudent resistance to televised classes, may be over- ome by appropriate lecturing techniques and proper dministration of the nontelevised parts of the course. elevised lectures do not appear to have an adverse ffect on learning.--Auth.

-2477. Proctor, Paul Dean. FIELD GEOLOGY OR THE ADVANCED STUDENT: Jour. Geol. Ed- cation, v. 9, no. 1, p. 39-46, 4 figs., Spring 1961.

Three phases of field-geology training for the ad- anced student are suggested: 1) preparatory or ffice-library phase, 2) field phase or direct accumu- lation of geologic observations, 3) communication hase or interpretation and write-up of data for the se of others. Suggested approaches and examples f each of these phases are cited. Application of the rinciples should result in a better trained and more ffective field geologist.--Auth.

-2478. Dolloff, Norman H. SUMMER INSTITUTE N EARTH SCIENCE AND MATHEMATICS FOR SEC- ONDARY-SCHOOL STUDENTS OF HIGH ABILITY: Jour. Geol. Education, v. 9, no. 1, p. 19-23, Spring 1961.

A study of the physics and chemistry of water, as an introduction to a survey of earth science, proved to be an effective procedure for 40 high-ability secondary-school students. This approach provided a basic resource of information and understanding on which students and teachers could draw in explaining diverse phenomena of the atmosphere, hydrosphere, and lithosphere.--Auth.

3-2479. Croneis, Carey. GEOLOGICAL PERSPECTIVE: Jour. Geol. Education, v. 9, no. 1, p. 1-12, Spring 1961.

The Presidential address, National Association of Geology Teachers, presented at Denver, Nov. 2, 1960. Teachers of geology should give their students widely ranging philosophical reviews as often as possible without upsetting class progress. Geologists will play less and less important roles in the future unless the knowledge to which they have unique access is brought to bear on the problems facing all mankind. The obsolescence of the "old-time" geologist is obvious, for example, in the new fields of power development which involve fission, fusion, and solar energy.

Historical geology has much to contribute to philosophical considerations of man as a unique animal and of earth as a unique environment. The paleontological observation that the oldest, most stable forms are the least adaptable to changing conditions has its analogies in the modern problems of man. It is possible, for example, that one of man's highest evolutionary adaptations, a moral sense, is one of his greatest threats to continued development, even survival. If it be true that high protein diets reduce the over-all birth rate, and low protein diets increase it, then man's humanitarian efforts to provide low cost cereal foods to the underfed masses of the world only aggravates the problem.--M. Russell.

AUTHOR INDEX